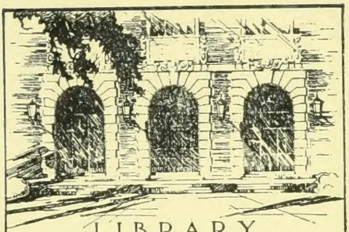

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AMERICAN GEOLOGIST.

Vol. XIX. JANUARY, 1897. No. 1

SKETCH OF W. W. MATHER.

By C. H. Hitchcock, LL. D., Hanover, N. H.

[Portrait, Plate I.]

William Williams Mather was born in Brooklyn, Connecticut, May 24, 1804. The first of his ancestors to arrive in this country was the Rev. Richard Mather, who had emigrated from England in 1635 and settled in Massachusetts. The distinguished president of Harvard College, Increase, and his son Cotton, the eminent divine and author, belonged to the same stock. The maternal grandfather, Nathan Williams, was a soldier in the war of the Revolution.

Young William became an adept in chemistry, and graduated at the West Point Military Academy in 1828. In 1826 he corrected and amended the proofsheets of a treatise on chemistry prepared by J. W. Webster, who was afterwards executed upon the gallows for the murder of Dr. Parkman. Webster failed to acknowledge his indebtedness to Mr. Mather in his preface, thus showing his lack of courtesy. After graduation Mather remained for eight years in the army, partly on regular duty, partly acting as professor of mineralogy, geology and chemistry at West Point and Wesleyan University, and lastly as assistant geologist to G. W. Featherstonhaugh in the exploration of Wisconsin Territory.

In 1836 he was appointed geologist of the "first district" of the state of New York, taking the place of Edward Hitchcock, who had resigned this position after about a month's field-work. Prof. Mather made five annual and one final report on the geology of this district. From 1837 to 1840 he had in charge the first geological survey of Ohio, preparing two annual and one special report upon the collections gathered during the explorations. He was also employed to conduct the geological reconnaissance of Kentucky in 1838, 1839, upon which he wrote a brief report.

After the suspension of the Ohio survey, Prof. Mather purchased a tract of land in Jackson county, Ohio, and became a citizen of the state. Subsequently he taught natural science in the Ohio University, at Athens, and at Marietta College. His abilities as a geologist led to frequent employment as an expert in the examination of mineral lands upon lake Superior, in Virginia, New York, Massachusetts, etc., during all the rest of his life. For several years he was connected with the Ohio State Board of Agriculture, either as secretary or chemist, and he was also the editor of the "Western Agriculturist." He died at Columbus, Ohio, Feb. 26, 1859.

Prof. Mather had a vigorous constitution, and consequent large ability to engage in scientific explorations, with the capacity to understand and describe natural phenomena and to speculate upon their causes. He possessed a gentle disposition, was manly, self-reliant, just in his estimates of others, not dogmatic nor ostentatious, ready to give up any theory when convinced of its falsity, and he held firm religious principles. Through an active and laborious scientific career of thirty years no suggestion of censure ever assailed his integrity. His work was well and faithfully done, and his name will always hold a place of honor among the geologists of his day.

Farther special statements as to the official positions held, as to honorary degrees and membership in various societies, and a list of his various published reports, papers, and books are appended. These were furnished by his son, Mr. Richard Mather, of Ironton, Ohio. For further biographical details the reader is referred to the memorial sketch prepared by Hon. Ivers J. Austin in the annals of the New England Historic and Genealogical Society, and to a similar notice in Appleton's Popular Science Monthly for August, 1896. The accompanying portrait represents Prof. Mather as he appeared at the age of fifty-three, not long before his death, when in the maturity of his powers. The portrait in the Popular Science Monthly was taken in 1846, when forty years of age.

The most important of Prof. Mather's writings may be the "Geology of the First District of New York," which afforded a larger list of formations than any of the other districts. It included—using the nomenclature of to-day—the Archean, Cambrian, Silurian, Devonian, Triassic, Cretaceous, Tertiary, and Quaternary. He must have been forward among his colleagues in the establishment of the "New York System" and in the use of local names for the subordinate divisions. In his report for 1840 this system was said to consist of the Catskill, Helderberg, Shawangunk, and Hudson River. The first included the Chemung, the third was composed of rocks quite different from the Niagara, Clinton and Medina, of the Ontario division, and the Hudson series embraced all the Lower Silurian, including the Potsdam. Two of the geologists—Hall and Emmons—excluded the Catskill from their enumeration, calling it simply "Old Red Sandstone." The order of description was from above downwards in obedience to the general usage of the time.

Mather had been commissioned by the American Association of Geologists in 1840 to present before them the subject of the "Drift." Not being in readiness to present his paper in 1841, and being absent from the next two meetings, he used the material, chiefly gathered in his own state, for his official report. This is unusually full and is one of the best presentations of the subject in his time. The Quaternary is divided into three parts, Alluvium, Quaternary proper, and Drift. The description of the first relates to fluviatile, lacustrine, and marine alluviums, low-lying sands, bars, mud flats, peat, marl, bog iron, tufa, beaches, shoals, spits, dunes, together with full descriptions of all the fossils contained in these deposits, especially the Infusoria [Diatoms]. This topic also embraced springs, caves, transportation by floating ice, the disintegration of rocks, and denudation.

The second division related to the modified drift—river terraces, beaches bordering the great lakes, sand and gravel plains, the meadows and sands of Manhattan island, and the marine deposits along lake Champlain and Hudson river. Thirdly, came the subject of the Drift—erratics, hardpan, lists of striæ, both for New York and other states. The description of the distribution of boulders and till over Long island is very full and complete, and was used by the writer in the preparation of a paper presented to the Lyceum of Natural History in New York and the Long Island Historical Society in 1868, entitled "The Geological History of Long Island." The facts of Mather's report were employed to illustrate the theory that the backbone of Long island constituted a part of the terminal moraine of the ice-sheet. Mr. Mather, however, followed his contemporaries in supposing that the dispersion of the boulders and the striation of the ledges resulted from floating ice in a time of general submergence. His objection to Agassiz's glacial theory was the common one of his day—that the flat lands of the middle western states did not offer a sufficient slope to produce motion in the ice-sheet. Owing to his connection with surveys in other states he says his conclusions were based upon what he had seen in over one hundred thousand miles of travel.

The study of the formations of Long Island enabled Mather to recognize both the Tertiary and the Cretaceous, though he used a local name for the group. The outcrops of the Trias were rather limited, but he correlated the sandstones with those of the Connecticut valley, and he suspected that the associated trap rocks might have been ejected in the Cretaceous. For the proper explanation of the distribution of the Trias in the Connecticut and Newark areas, with opposite dips, Mather first states and rejects the fluviatile hypothesis of H. D. Rogers and then proposes a new theory based upon the courses of the equatorial or gulf stream and of the returning polar current. The first stream being directed through the Connecticut valley would naturally deposit sediment upon an easterly slope, and the returning polar current having a westerly tendency would drop its burdens upon the Palisade side of the Hudson.

No part of this report has attracted more attention than his conclusions respecting the rocks east of the Hudson river. His colleague, Emmons, as is well known, had proposed an interpretation for certain formations in this district not accepted by any other one of the board of geologists except in part by Vanuxem. These rocks consist of a series of great thickness, sandstone, limestone, and slate, to which Emmons gave the name of Taconic System, and supposed them to underlie the Potsdam sandstone, then esteemed as the base of the Silurian system. Inasmuch as these rocks did not occur in the second district, Emmons could not legitimately describe them in his official report except cursorily; nor could his views be properly illustrated upon the general geological map compiled from the reports of all the geologists. Hence he was compelled to state his views in a volume prepared later upon Agriculture, and to draw his illustrations largely from the adjoining states of Massachusetts and Vermont. This divergence of views led to the Taconic controversy—a discussion that became very bitter between its chief disputants—comparable in intensity and duration to the similar conflict in England between Sedgwick and Murchison over the Cambrian and Silurian. In fact the principles involved were identical upon the two continents. Connected with the stratigraphical discussion arose the subject of metamorphism, which was unnecessarily controverted by Emmons and advocated by Mather.

On these subjects Mather held: (1) The "Taconic rocks are the same in age with those of the Champlain Division, but modified by metamorphic agency and the intrusion of plutonic rocks." p. 438. (2) The limestones that are frequently crystalline white and variegated marbles, talcose slates and quartz rocks of Dutchess, Putnam, Westchester, and New York counties are metamorphic rocks. They were originally "the rocks of the Champlain Division, but much more altered and modified by metamorphic agency than the Taconic rocks." page 464. (3) The Primary [Archean] rocks are extensively developed in the highlands of the Hudson, in New York, Westchester, Putnam, southern part of Dutchess. parts of Orange and Rockland counties, and Staten island. The kinds of ores and rocks correspond with those in the northwest part of the first district, in the Adirondack region.

The views of Mather on all these points would not essentially vary from those recently presented by professor James

Hall and Mr. F. J. H. Merrill in their respective geological maps of the state. This statement, however, assumes that Mather would have accepted certain modifications of presentation, such as the use of the terms Cambrian for the primordial fauna and the acceptance of the belief that the Granular quartz of Emmons is not the equivalent of the Potsdam but a much lower horizon.

Mather's name has been mentioned in connection with the suggestion that the State Geologists should meet for consultation, and with their co-workers form an association of geologists. In November 1838, not being able to be present at the meeting, he addressed a letter to the New York board of geologists, presented through professor Emmons, commencing as follows: "Would it not be well to suggest the propriety of a meeting of the geologists and other scientific men of our country at some central point next fall, say in New York or Philadelphia. There are many questions in our geology that will receive new light from friendly discussion and the combined observations from various individuals who have noted them in various parts of our country. Such a meeting has been suggested by professor Hitchcock and to me it seems desirable," etc.

From a letter of Mather to Hitchcock in 1849, it appears that professor Vanuxem made the motion before the Board to adopt the suggestion; and it is a well known fact in history that this vote led to the formation of the "American Association of Geologists," followed several years later by the American Association for the Advancement of Science.*

The Geological Survey of Ohio was carried on during the years 1837 and 1838. Greater help was obtained from assistants than in the New York survey. As the result of these two years of labor Prof. Mather was enabled to establish the column of formations, whose accuracy was certified to by the later works of Dr. J. S. Newberry. The basal rock is the "Blue limestone" or Lower Silurian, followed by the "Cliff limestone," which has been identified with the Upper Silurian and Lower Devonian. The succeeding "Black slates" are Upper Devonian. The "Waverly sandstone" finally proves to be the lowest Carboniferous, though referred to the Portage and Chemung groups in 1842 by professor Hall. The two latest members are the Conglomerate or Millstone grit and the Coal Measures. He found the beds of coal to be of great value, and interested himself in his later life by investing in these lands and laboring earnestly for their development. The great industries located in Ohio, dependent upon coal and iron, amply confirm the correctness of the judgment of Prof. Mather in those early days of their great value.

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*The correspondence relating to this subject is given in the Tenth Annual Report of the Regents of the University on the State Cabinet of Natural History, page 23. It seems that Hitchcock wrote on this subject to Mather in 1837 and 1838.

Mr. Mather received the degree of M. A. from Wesleyan University, Middletown, in 1834, and that of LL. D. from Brown University in 1855.

He was a member or corresponding member of numerous scientific societies, among which may be named:

Yale Natural History Society, New Haven, 1836.
Lyceum of Natural History, New York, 1837.
Academy of Natural Sciences, Philadelphia, 1838.
Association of American Geologists, 1840.
Association of American Geologists and Naturalists, 1841.
National Institute, Washington, D. C., 1842.
American Association for the Advancement of Science, 1847.

He was also a member of various philosophical and historical societies, viz.:

Ohio Philosophical and Historical Society.
Connecticut Historical Society.
Historical and Geological Society of Norwalk, O.
Minnesota Historical Society.

He was trustee of Granville College, O., from 1840 to 1855, and a life member and director in many religious organizations.

List of Official and Professional Positions held by W. W. Mather.

1828.

Brevet Second Lieutenant, U. S. Army, July 1st, 1828.

Acting Assistant Instructor of Artillery at West Point during the encampment, June, July and August, 1828.

Assigned to duty with 6th Regiment Infantry at Jefferson Barracks School of Practice, 1828.

Promoted to Second Lieutenant, 7th Infantry, July 1st, 1828.

1829.

Ordered to 7th Regiment at Fort Jessup, April, 1829.

Ordered to West Point as Acting Assistant Professor of Chemistry, Mineralogy and Geology, June 29th, 1829, and remained on duty there until June, 1835.

1833.

Acting Professor of Chemistry, Mineralogy and Geology at the Wesleyan University at Middletown, Conn., during the recess of his course of instruction at West Point, by permission of the Secretary of War.

1835.

On topographical duty, June to December, 1835, as Assistant Geologist to G. W. Featherstonhaugh, making a geological examination of the country from Green bay to Coteau des Prairies; and Mr. Mather made a report and a topographical map of the St. Peter's river valley of Minnesota.

Ordered to Regiment at Fort Gibson, November, 1835, and marched into Choctaw country May, 1836, in command of Company D, 7th Infy.

1836.

Resigned from the Army, August 23d, 1836.

Appointed Professor of Chemistry, Min. and Geology in the University of Louisiana. 1835. Declined.

Geologist of the First District (S. E. quarter) of New York, containing 21 counties, from July, 1836, to 1844. (Made five Annual Reports and one Final Geological Report.)

1837.

Geologist superintending the Geological Survey of Ohio from 1837 to 1840. (Made two annual reports and one on the collections).

1838.

Geologist making a Geological Reconnaissance of Kentucky, 1838 to 1839. (Made one report).

1842.

Professor of Natural Science in the Ohio University, 1842-1845.

1845.

Vice-President and Acting President, and Professor of Natural Science at the Ohio University, 1845.

Geologist and Mining Engineer to various mining companies on Lake Superior in 1845, 1846 and 1847, and others in Virginia, New York, Massachusetts, etc.

1846.

Acting Professor of Chemistry, Mineralogy and Geology at the Marietta College, Ohio, January to March, 1846. Acting temporarily. Unwilling to accept the professorship in consequence of other arrangements.

1847.

Vice-President and Professor of Natural Science in the Ohio University, 1847 to December, 1850.

1850.

Delegate of the Jackson County Agricultural Society to the State Agricultural Convention of Ohio, annually 1850, 1851, 1852, 1853, 1854, 1855, 1856 and 1858.

1850-4.

Corresponding Secretary of the Ohio State Board of Agriculture 1850-1854. (In charge of the office of the Board, conducting the correspond-

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ence with the State Societies of other states, with foreign Agricultural Societies and individuals, and with the 80 County Agricultural Societies subordinate to the Board. Also charged with preparing all the publications of the Board, the fairs in their details, and distribution of the awards.)

Agricultural Chemist of Ohio for the State Board of Agriculture, analyzing soils, ores, coals, water, salines, etc., and making Agricultural and Geological surveys. (Vide reports in Reports of Ohio State Board of Agriculture.)

1851–2.

Editor of the Western Agriculturist, Jan'y 1st, 1851, to July 1st, 1852. (First volume and one-half of second volume.)

1852.

Delegate to the U. S. Agricultural Convention at Washington city for the Ohio State Board of Agriculture, June, 1852.

1853.

Geologist of Lieut. Williams' part of exploration for the Pacific railroad across the Sierra Nevada, May, 1853. Declined. Disabled by a snake bite (supposed to be) and partial paralysis consequent, and amputation necessary.

Geological Engineer, making surveys of the available mineral resources of the Lexington and Big Sandy railroad in Kentucky .

1853–4.

Member of the U. S. Board of Agriculture for Ohio.

1854.

Appointed Lecturer on Agricultural Science in the Dennison University, Ohio. Declined.

1855.

Geological Engineer making the survey of the available mineral resources on the line of the Pittsburg, Maysville and Cincinnati railroad in Ohio.

Member of the Board of Visitors appointed by the president to attend the examination of cadets of the U. S. Military Academy at West Point, New York, and report to the Secretary of War.

1856–7.

Manager to build and put in operation Oak Ridge furnace, in Lawrence county, April 30th, 1856, to December 14th, 1857, when the furnace was in full operation from August 5th, 1856, to December 14th. 1857. Director in said Furnace Co. from August, 1857.

Writings of W. W. Mather.

1828.

On the non-conducting power of water with regard to heat. American Journal of Science and Arts, vol. XIII, p. 368.

1830.

Report on the analysis of the Lycoming Iron ores, (to Geo. Carpenter). Vide Mather's manuscript, "Chemical Researches," March, 1830, page 37.

On the crystalline form of Iodine. Am. Jour. Science, XVIII, p. 184.

On the crystalline form of Xanthite. Am. Jour. Science, XVIII, p. 359.

1831.

On the production of Aluminum and Magnesium. Am. Jour. Science, XX, p. 408.

1832.

Geological notes and Geological Section in Connecticut. Geological notes on the Highlands of New York. Am. Jour. Science, XXI, p. 94.

1833.

Sulphurets of Bismuth, and formation of a new compound--the disulphuret. Am. Jour. Science, XXIV, p. 189.

On the principles involved in the reduction of Iron and of Silver ores, with a supplement on the principal silver mines of South America. Am. Jour. Science, XXIV, p. 213.

Elements of Geology for the use of Schools. Published at Norwich, Conn., by William Lester.

1834.

On Diluvion, for the use of the Cadets of the U. S. Military, West Pt. (part of the Geological Course). Lithographed by the U. S. Military Academy at the Academy Press.

Geology and Mineralogy of Windham and New London Counties in Connecticut. Published at Norwich, Conn., by William Lester.

Geological Map and sections of the above Counties on Lester's Topographical Map of Windham and New London Counties. Published at Norwich, Conn., by William Lester.

Report on the Salisbury Iron Ores and their reduction. Vide Mather's manuscript, "Chemical Researches," vol. I, page 85.

Survey and Report to ——— Bacon on the Simsbury Copper Mines, and analysis of the ores. Vide Mather's "Chemical Researches," vol. II, page 57.

1835.

Contributions to Chemical Science, viz: (1) On Chloride of Aluminum and its analysis, and the atomic constitution of the chloride and oxide of aluminum. Am. Jour. Science, XXVII, p. 241.

(2) A hydrated chloride of aluminum and its analysis, and its atomic constitution deduced. Am. Jour. Science, XXVII, p. 253–256.

(3) Crystallized tin from solution (a new method). Am. Jour. Science, XXVII. p. 254–255.

(4) Georgia Gold. Analysis of the Georgia Gold Assayers. Am. Jour. Science, XXVII, p. 255–256.

(5) Silver of Lane's mine, Monroe, Conn. (Auriferous) Analysis of and remarks on other minerals of that mine. Am. Jour. Science, XXVII, p. 256–257.

(6) Potash Iodide of Platinum, its preparation, decomposition and atomic constitution. Am. Jour. Sci., vol. XXVII, p. 257.

(7) Cloriodide of Platinum, its preparation, decomposition and atomic constitution. Am. Jour. Sci., vol. XXVII, p. 258-262.

(8) Crystallized Perchloride of Platinum, analysis and atomic constitution, (a hydrated perchloride). Am. Jour. Sci., vol. XXVII, p. 262-263.

(9) Amalgam of Platinum, a new and easy method of preparation. Am. Jour. Sci., vol. XXVII, p. 263.

(10) Iodide of Mercury, solvents and properties. Am. Jour. Sci., vol. XXVII, p. 263.

(11) Bitungstate of Ammonia, solubility in water determined, and re-agents for. Am. Jour. Sci., vol. XXVII, p. 264.

(12) Disulphuret of Bismuth, with analysis and atomic constitution. Am. Jour. Sci., vol. XXVII, p. 264.

Report on the Geological Reconnaisance between Green bay and the Coteau des Prairies, by Lt. W. W. Mather, on topographic duty, as assistant to G. W. Featherstonhaugh. Manuscript report sent from the Arsenal, near St. Louis, Mo., in November or December, 1835, to Lt. Col. J. J. Abert, of Topographical Bureau, Washington. Returned to the author in 1851, at his request.

Topographical sketch of the valley and meanderings of the St. Peter's river, accompanied the above report, from plotting courses and distances. Sent with the above report, but not returned with the report to W. W. M.

1836.

Report on the Martinsburgh Lead Mines and Ores.

Instrument proposed for measuring accurately the expansion of solid bodies, and which may be used as a thermometer, and is also adapted for testing standards of length, and for Geodetical operations, Am. Jour. Sci. and Arts, XXX, p. 324.

1837.

First Annual Report on the Geological Survey of the First, or S. E. District of New York, made December, 1836. State Assembly Doc. No. 161, p. 63-97, 1837.

Report on Gold Mines of North Carolina. [To McIntire, Gregory & Co.]

Second Annual Geological Report of the First District, N. Y. Assembly Doc., 200 of 1838, p. 121-184.

Report on a reputed coal tract in Pennsylvania.

1838.

Geology for use of schools and academies. Revised, enlarged and stereotyped. Published and stereotyped in New York by J. Arnville Taylor. [This work passed through several editions in successive years, until the publication was ordered to be stopped by W. W. M.]

First Annual Geological Report of Ohio. Ohio, Assembly Doc.

Third Annual Geological Report of New York. Assembly Doc. 275, p. 67-196.

Second Annual Geological Report of the Ohio Geological Survey. Assembly Doc. Reports.

1839.

Report on the Coal-Grove Coal and Iron property, with a description of its resources, and a minute topographical and geological map, and sections from actual survey, 4,000 acres in Lawrence County. Published by the Coal-Grove Co. in Columbus, in 1839, and in New York in 1847 by J. L. Minen & Co.

Geological Report on the "Geological Reconnaissance of Kentucky, made in 1838." Assembly Document, 1839.

On Cupellation, an easy and accurate method with the blowpipe. Am. Jour. Science, xxxv, p. 321.

1840.

Fourth Annual Geological Report of New York. State Assembly Doc. No. 50, pp. 209-258.

1841.

Fifth Annual Geological Report of New York. Assembly Doc. No. 150, p. 57.

1842.

Report to the Legislature on the arranged Geological Collections for the State Cabinet, and those prepared for distribution to the Colleges and Universities of Ohio, collected on the Geological Survey. Ohio Assembly Document. Reports, 1842.

Report on the coal mines near Owensborough, Ky., [to Hon. Robert Triplett]. Published in Kentucky.

1843.

Final Geological Report of the First District of New York, entitled "Natural History of New York, Part IV, Geology, by W. W. Mather, Vol. I." This is a quarto volume of 653 pages and 46 colored plates. Published by the State of New York in 1844, as one of the volumes of the Natural History of New York.

1844.

On the possible variation of the length of the day, or of the revolution of the earth on its axis, with corrected formulæ of the appendix of the Final Geological Report of New York. Am. Jour. Science, xlvi, p. 344.

On the Geology of the United States east of the Rocky mountains, and an enquiry into the causes that have led to the deposition of the sedimentary rocks, and that have caused their elevation and contortion. Am. Jour. Science, xlix, p. 1; 284. (This great physical question is considered and partially developed. This paper was written for and read before the National Institute at Washington, April, 1844, and probably published by them also, and before the American Association of Geologists and Naturalists in May, and before the Athenian * * * * by request in August.)

1845.

On Bromine and Iodine in the Ohio Salines. Amer. Jour. Science, xlix, p. 211.

An extended series of investigation was entered into, many new compounds formed, improved methods of extracting bromine contrived and put in operation, with a view to manufacture, but most of the papers were lost during his absence on lake Superior in 1845-6-7. Those that remain are in an incomplete state, and neither published nor prepared for publication.

1847.

On Cupellation with the blowpipe, and on accurate methods of quantitative estimation of minute quantities of silver and gold. Am. Jour. Science, (New Series) p. 409.

On the meteorology of Lake Superior and the causes of the sudden and gradual changes of the level of the waters of the Lakes. Am. Jour. Science, VI, p. 1–20.

Two reports to W. P. Cutler, President, and to A. B. Walker on the mineral resources along the line of the Cincinnati and Belpré railroad. Published in pamphlet form with the report of the President, 1848-9.

1848.

Report and Topographical and Geological Map and sections of 7,500 acres of coal and iron land. the Robertson tract in Southern Ohio.

Premium Essay on the Mineral Kingdom being the source of the matter of the Animal and Vegetable Kingdoms. Third Annual Report of the Ohio State Board of Agriculture.

1849.

Report on the practicable routes for the Scioto and Hocking Valley R. R. Various routes suggested and discussed. The route recommended was adopted and the road built. Scioto County papers at Portsmouth, Nov. to April, 1849-50.

The question argued on the propriety of a county subscription of $100,000 by Jackson County to the R. R. Co. This question argued and all the objections answered, and advantages set forth. Resulted in a vote of 4 to 1 in favor of the county subscription. Published in the Jackson Standard, March 14-21-28, 1850. Copied into other papers. Arguments used in various counties.

1850.

Report on the agricultural productions and the resources of Jackson County, O. Fifth Annual Report of the Ohio State Board of Agriculture.

Rotations of timber growth. Ohio Agri. Rep.. 1850.

Edited the Fifth Annual Report of the Ohio State Board of Agriculture. Assembly Document.

1851.

Edited the Western Agriculturist, Jan. 1851, to July, 1852. Vol. I, pub. by J. H. Riley. Vol. II, pub. by S. Medary.

1852.

Edited the 6th Annual Report of the Ohio State Board of Agriculture. Assembly Document.

Report as Corresponding Secretary to the Ohio State Board of Agriculture. Sixth Annual Report Ohio State Board of Agriculture.

Report on the Analysis of soils of Ohio, as Agricultural Chemist of Ohio. Sixth Annual Report Ohio State Board of Agriculture.

Essay on the soils of Ohio, their geological relations, characters, deterioration, renovation, mineral elements of parts of plants, composition of soils. Sixth Annual Report Ohio State Board of Agriculture.

Edited the Seventh Annual Report of the Ohio State Board of Agriculture. Assembly Doc., 1853.

Report on the Agriculture of Jackson county, and on the mineral resources, particularly on the line of the Cincinnati, Hillsborough & Parkersburg R. R. Seventh Annual Report, Ohio State Bd. Agri.

Report on the mineral resources along the line of the Cincinnati, Hillsborough & Parkersburg R. R. [To Elwood Morris, for the Company.] Published in pamphlet form by the R. R. Co., with the reports of the president (Trumble) and engineer (Ellwood Morris).

Report as Corresponding Secretary of the Ohio State Board of Agriculture, and Agricultural Chemist of Ohio: Analysis of Soils, modes, and desiderata, and objections answered; modes of improving the interests of agriculture; analysis of the waters of Cleveland; analysis of Ohio coals; agricultural reconnaissance of Ohio. Seventh Annual Report, Ohio State Bd. Agri.

Report on the analysis of the River, Lake, Well, and Spring Waters at Cleveland. [To the Water Commissioners.] Published in pamphlet form by the Water Commissioners, 1853.

Report on the analysis of various coals in Ohio, with reference to their purity, heating power and adaptation for various uses. The tabulated results are in Seventh Ohio Agri. Report.

1853.

Report on the great coal bed at Straitsville. [To - — Sullivan, President C. O. R. R.] Am. Jour. Sci., vol. x, p. 450.

On the Argentiferous Galena of Arkansas. Am. Jour. Sci., vol. x, p. 450.

Report to the Ohio State Board of Agriculture on the importance of prosecuting a Geological and Agricultural Survey of Ohio. Read before the Board and to have been published, but lost when before the Legislature.

Report to the Ohio State Board of Agriculture on the means necessary to elevate agriculture to a liberal art and science. Read before the Board, etc., as above.

Essay on the same subject, and on the importance of analyzing the soils, grains, and other parts of cultivated plants from various parts of the United States. Sent to the U. S. Agricultural Society as one of the Board, and filed for publication in its transactions.

Report on the mineral resources available along the Lexington & Big Sandy R. R. [To R. Apperson, President R. R.] Published by the Company at Lexington, in the papers, and in pamphlet form.

1854.

Report on the great coal bed in Perry county, and the coal lands available on this bed to the Scioto and Hocking Valley R. R. [To Israel Dille, Esq.] Published in New York.

Duties on railroad iron should not be remitted. Rail Road Record, II, p. 389.

American and foreign railroad iron. Reasons why railroad iron has not been manufactured more extensively in the United States. Rail Road Record, II, p. 569. Mining Magazine, N. Y., III, p. 457-8.

On American and foreign railroad iron. Means by which United States railroad iron can be sold as cheaply, and on as good terms of credit, as the Welsh railroad irons. Rail Road Record, II, p. 582. Mining Magazine, N. Y., III, p. 570-8.

On the Black Band iron ore of Ohio. Its abundance. Published in the Mining Chronicle.

1855.

Report of the mineral resources available along the Pittsburgh, Maysville & Cincinnati R. R. [To Thos. W. Peacock, President.]

Report on the discipline in the U. S. Military Academy.

General Report of the Board of Visitors at the U. S. Military Academy, June, 1855.

Report on the coal supply of Cincinnati, and a consideration of all the available resources of supply, with the cost of delivery, and qualities of the coals.

Notes on the iron region and furnaces of southern Ohio. Am. Mining Chronicle, vol. x, p. 68, Sept. 1st, 1855.

1859.

Report on the State House artesian well at Columbus, O. 42 pp.

THE STUDY OF NATURAL PALIMPSESTS.

By G. P. Grimsley, Ph. D.

Paleontology has revealed a long life history from Cambrian time to the present and has vainly attempted to read the obscure pages of the earlier history of Archean time. Baffled at every turn the search was abandoned, but a new science has boldly entered the field and the mysterious pages furnish a history for the *petrographer* which in interest rivals that of the paleontologist.

This record is not written in fossil letters but in mineral characters, which so long have been meaningless *geoglyphics*. In making the so-called pre-historic record nature has been economical in materials and in space. She has erased some portions of the ancient record with the cleansing force of fire, rewriting on the same tablets of stone the records of new conditions.

The discovery that many of the records of ancient historical time were written on the erased parchments of an earlier day and that a careful investigation would reveal many of the first records, was a historical triumph. The students of ancient languages have enriched the world by their painstaking search through old literary palimpsests. In the past decade the students of nature have discovered the existence of *natural palimpsests* and they are now endeavoring to read the imperfectly erased records of the past, and thus add new chapters to the history of the earth. To the process of erasure and rewriting these investigators have given the name *metamorphism*, and the natural palimpsests are called *metamorphic rocks.*

The studies of the biologists have shown that throughout organic nature there is a most delicate adjustment to environment. The researches of petrographers have shown that in the inorganic world minerals are so delicately adjusted to surrounding conditions that changes in the latter are recorded by variations in the minerals. The recognition of this fact in recent years is the foundation of the new knowledge concerning the Archæan period.

According to the Wernerian theory of the last century, crystalline rocks were deposited as chemical precipitates from a primeval heated ocean before life existed; they were produced at their origin as they exist to-day. Near the close of the century, Hutton found granite dykes penetrating other rocks, thus proving an igneous origin. He then advanced farther and formed the interminable cycle, stating that rocks were decomposed by atmospheric action, the detritus accumulated at bottom of the sea, where under the pressure and heat it was rendered crystalline, and later elevated to pass through the same series of changes without trace of beginning or prospect of end. The theory of the transformation of rocks under heat and pressure originated at this time in this rudimentary form in Scotland. Bone and Necker, nearly a quarter of a century later, transported the theory from this plutonic region to Europe where it reached greater development. The Alpine region, on account of the great forces at work and the gradations in effects, from simple to complex, soon became the classic region for the study of rock alterations. In 1826 Beaumont recognized that in this region the phenomena were not confined to the oldest rocks. He observed that Jurassic fossil sediments had been changed to crystalline rocks. The old Alps now became the new Alps and the interest in the region was greatly increased.

In the process of adjustment of the minerals or rocks to changes in their environment new elements are often added and old ones removed. If the changes take place at the surface of the earth, under ordinary atmospheric or aqueous influences, they are included under the term *weathering* and the result is usually disintegration. True metamorphism is connected with igneous and dynamic agencies; and while the word was first introduced by Lyell in 1832, it was not clearly defined until 1846, when Durocher described metamorphism as the sum total of all modifications in texture or structure to which rocks in nature are subjected. Daubrée limited the definition to those modifications whose causes were fire and water, and Beaumont added the agency of mineralizers. The word metamorphism is now cosmopolitan, though given different limitations by different authorities.

American geologists from an early day have been prominent in this field of study. The pioneers composing the American metamorphic school, Hitchcock, Mather, Dana, Logan, Rogers brothers, were active students of these altered records and they made many valuable observations. They all regarded the process of metamorphism as confined to the sedimentary rocks, a view which long retarded progress in the work. When foliated or parallel structures were observed in metamorphic rocks they were regarded as the old sedimentary lines which survived the alteration. A voluminous literature descriptive of this limited field of altered sediments soon filled the shelves of science.

Down to the year 1875 the province of metamorphic action was thus confined to sedimentary rocks. About this time appeared the epoch-making works of Heim in the Alps and of Lossen in the Harz, whereby it was shown that igneous rocks could be changed by metamorphic action.

On account of the interesting and inviting problems connected with this study, it has attracted the attention of many of the younger workers; and the result has been a very great advance in our knowledge of these broken and crumpled rocks, though the vast field yet remains practically unexplored.

Metamorphism may refer to any change in rocks, but it is restricted now to include the changes whose conditions lie intermediate between fusion and ordinary atmospheric action. The limits are not sharply defined, so metamorphism grades below into igneous action, and above into atmospheric action or weathering. Metamorphic rocks may be further metamorphosed so that all rocks, sedimentary, igneous and metamorphic, are subject to metamorphism. The agencies at work in this great process are both physical and chemical and they are classified according to the preponderating influence. If the temperature and pressure are low the action is due mainly to water, producing *hydro-metamorphism*, resembling very closely weathering. If the temperature is high and pressure is low, and mineralizers—gases whose presence facilitates fusibility—are present the action is described as *sublimation-metamorphism*; or, if water alone be present, the action is described as *thermo-metamorphism*. *Static-metamorphism* includes those changes where pressure is mainly active and where motion is absent. If motion is present the changes come under the division of *dynamic-metamorphism*. All of these alterations take place without any material change in bulk composition. Static metamorphism, though not accepted by many geologists, has able defenders in such men as Hall, Judd, Spring. Dynamical metamorphism has been firmly established by the classic works of Heim, Lehman and Balzer.

Metamorphism may be produced by the presence of some metamorphosing agent, and it is then termed *contact metamorphism*. The alteration in surrounding rocks may extend over a distance from a small fraction of an inch up to 4,000 feet, as seen in the Pyrenees. The nature of contact metamorphism depends on the duration of the action, the depth at which the alteration takes place, whether deep enough to prevent escape of the vapors and moisture or not; and on the nature of the metamorphosing agent whether this is a granite, diabase or other rock; and also on the nature of the rock altered, whether crystalline schists, carbonaceous rocks, sandstones or igneous rocks. The nature further depends on the structure of the rocks, whether foliated or not, as demonstrated in Brittany by Barrois.

Rosenbusch, after a careful examination of analyses, concludes that there is no change in the bulk composition of the altered rocks, though Michel Levy insists that there is always a very considerable addition of substance.

The effect of contact metamorphism on the crystalline schists is less intense than on most of the rock types. The effects, consisting mainly of formation of new minerals, as andalusite, sillimanite and garnets, have been described in the Cortlandt rocks by the late Dr. G. H. Williams. The effect of this form of metamorphism on carbonaceous shales is to form graphite, or the diamond, as in the South African region. The effects of contact action on clay slates have been described at a number of regions which serve as types; at Barr Andlau, in Germany, by Rosenbusch, by Lossen in the Harz, by Allport and Phillips in England, by Barrois in Brittany, Brögger in Norway. In these various regions it has been noted that the intensity of metamorphism at any given point is proportional to the nearness of the intruding rock.

In limestone contacts the conditions are very favorable for tracing the beginning and development of the metamorphism. The limestone is observed to become more and more crystalline as the intrusive rock is approached and the carbonates change to silicates. These changes are observed in the well known limestone contact region near Christiana, in Norway, and in the famous mineral locality of the Fassathal in the Tyrol. Contact action on igneous rocks has been observed at but few places. It has been described by Lossen in the Harz mountains.

The pioneer in the study of dynamic metamorphism was Lossen in 1867. In 1878 Heim published his great work, the result of a long field study of the Alpine rocks, in which he developed the theory that even the most brittle rocks under pressure acted as viscous bodies and were deformed without rupture. Spring and Guembel endeavored to prove this theory by actual experiment, but the rocks were crushed to a fine powder.

In 1884, Lehman, as a result of microscopical study of the crystalline schists of the Alps, concluded that the rocks were crushed and recemented under great pressure, thus producing an effect similar to viscous bodies, a process which might be described as rock regelation. These two works mark a new phase in the study of metamorphism the world over, through the recognition of the fact that *foliation* in rocks is wholly independent of original structure. Parallel arrangement in rocks is not proof of sedimentation, a view which before this time was not recognized.

Heat, water and pressure are the great agents of metamorphism, and they produce three kinds of alterations in rocks, mineral, microstructural and macrostructural changes. Under mineral changes, we have among the alkaline silicates the alteration termed *sericitization*, forming an interlacing network of hydromicas. Also *saussuritization*, embracing the changes whereby the plagioclase feldspar is converted into alkaline earth silicates. In *albitization* the feldspar is changed into an interlocking albite mosaic. Among the iron-magnesian silicates occurs: *uralitization*, where pyroxene is changed into fibrous hornblende, *viridization* or formation of green epidote chlorite mass, analogous to saussuritization, *chloritization* and *epidotization*, analogous to albitization.

Under microstructural changes are observed the strain phenomena in crystals, recognized by polarized light in a wavy extinction of the light as the section is rotated. If the strain has been carried farther, gliding or twin lamellæ may be observed, as in the metamorphic marbles. Progressing to greater extent the minerals are bent, twisted and finally broken into an irregular mosaic, composed of interlocking mineral grains. Sometimes there is a stretching of the rock along certain lines, pulling the grains apart.

Under macrostructural changes, the most prominent is the formation of secondary foliation or an arrangement of the minerals along parallel lines, which were so long taken as evidence of stratification. Though this distinction between foliation and sedimentary lines was noted early in the century by Voigt, Mohs, and Schmidt, it attracted little attention. Later it was observed that the lines were parallel over extensive tracts, even when the rocks were crumpled. This was explained as the result of crystalline force or result of electrical currents passing around the earth. In 1846 it was shown to be due to pressure normal to that which developed the foldings.

Such rocks which possess this secondary foliation are called *crystalline schists.* This is a purely structural term and has no connection with age. While most of these rocks are pre-Cambrian, there are numerous exceptions. The schists are divided into two main groups, those with feldspar and those without this mineral, and the former are called *gneisses*. This usage makes gneiss a mineralogical and structural term; mineralogical in that it contains feldspar, structural in that it is foliated. If the origin of the gneiss is determinable it has the original rock name added as a prefix. Thus a secondary foliated conglomerate is called a conglomerate gneiss, a foliated granite is a granite gneiss. When the word gneiss is used alone it represents a foliated feldspathic schist of unknown origin.

Down to the end of the last century geology was a collection of hypotheses and sacred theories of the earth. Its students then began to observe and record facts, and later to form theories based on such observed facts. The study of the igneous rocks passed through a similar course of development. The study of the metamorphic rocks is now passing through such a course and it has entered the descriptive stage. It is now at the point reached by general geology in the time of Lyell, and reached by the study of the igneous rocks in the year 1870.

The study of the crystalline schists, both of Archæan and post-Archæan time, now becomes the great field for work and all over the world students are trying to trace their origin and formation.

Washburn College, Topeka, Kansas.

THE GALENA AND MAQUOKETA SERIES.

By F. W. Sardeson, Minneapolis, Minn.

Part II.

New Classification.

In the first part of this paper it has been shown that the local classifications of the Maquoketa and Galena series are discordant, and that a more complete and generally applicable system, which will embrace the elements of truth contained in each, ought to be substituted. The entire succession of strata that go to make up the Galena and Maquoketa together, is divided into about fourteen easily recognizable beds, that are, as a rule, co-extensive and continuous, and that are the component parts of all the locally designated series, formations and beds. By tracing each division continuously, we have a means for determining the value of each series and each formation, and for reducing them to uniformity. Thus it is easily proven that the basal demarcation of the Galena series is correct and uniform throughout, as heretofore known, and, indeed, the same is unmistakable because marked by the striking contact between St. Peter sandstone and the Buff limestone bed. So, likewise, the top of the Maquoketa series, which is followed by the Niagara limestone, or by the so-called Hamilton limestone, is, in either case, marked by a sharp lithologic and faunal break, which is not easily mistaken. But not so with the demarcation between the Galena and Maquoketa series, where no one horizon presents an unmistakable contrast as compared to any other.

At Galena, Illinois, the Galena formation is lithologically, as it were, extended up into the Maquoketa, for the topmost bed, (number 10) contains a fauna belonging most properly with that of the Maquoketa (Hudson). Thus, also, at Dubuque, Iowa. In northeastern Iowa and in Minnesota, on the contrary, this bed has been called Maquoketa shales and mistaken for the true Maquoketa because of its sedimentary and faunal aspect. Here, as in Illinois, are found *Orthis subquadrata* H., *O. kankakensis* McChes., and varieties (or species) of *O. testudinaria* Dal., of *Plectambonites sericea* Sow., of *Ischadites* and of *Asaphus*, such as belong to the Maquoketa and not those of the Galena series. With them are others that are common to both the Galena and the Maquoketa series. The lithological character of the Galena extends in some places to the top of this bed, but faunal characters of the Maquoketa series are found everywhere, down to the base, and hence I prefer the latter for the divisional line.

Mr. White, who first applied the name Maquoketa, intended, as he says, to "use the name Maquoketa shales to designate that particular epochal subdivision or formation of the (Cincinnati) group which alone is found in Iowa."* At the type locality, Graf Station, Iowa, there is extant the transition bed just mentioned, and two other formations. The transition bed he certainly did not include in the Maquoketa. The second part is the one that is described by him and by others. The third and uppermost one was not then exposed there, and was not described as different from the exposed portion,—which it certainly is,—but was included within the limits of the Maquoketa, as a matter of course. Strictly in accord with the letter of Mr. White's definition, three formations should be included in the Maquoketa, but the middle one only was described by him. I propose, therefore, to include all three under the name of Maquoketa (Hudson) series and to call the middle one Maquoketa formation. Otherwise the term might be rejected, as Jos. F. James has suggested.*

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*Geology of Iowa, vol. I, p. 181, 1870.

The Galena series has been long since divided into two formations, the "Trenton proper," or Beloit formation, and the Galena formation. The distinction was at first based on the lithological phenomena, the lower formation having thinner, more compact strata, the upper, thick porous ones; but this difference, which is best recognizable in the "lead region," is not quite satisfactory, since local alteration of the rock has produced the typical Galena facies in the top of the Beloit formation, or again, the base of the former is little changed like the latter. A faunal distinction is needed in addition, and one is easily found. Taking the divisions as recognized by Prof. T. C. Chamberlin, in southern Wisconsin, the Beloit formation is the zone of *Orthis subæquata* Con., (*O. perveta* Con., etc.), and the Galena is the zone of *Receptaculites oweni* H. The Galena, as defined in that way, does not include the transition bed (number 10, see diagram, p. 24), and the same not being properly included in the Maquoketa formation, I have placed it as a separate formation, as part of the Maquoketa series. The Maquoketa series may now be divided exclusive of the Transition formation, into two formations of which the lower is the Maquoketa formation, the upper the Wykoff formation, as I previously designated it in Minnesota, and the two represent, so far as I know, what authors have now and then alluded to as upper and lower Maquoketa, respectively. The relations of the five formations are shown in the diagram on the next page.

The division line by which the two chief groups, the Galena series and Maquoketa series are divided, is only in a small degree more constant and distinct than those between the des-

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*American Geologist, vol. v, p. 335, 1890.

Ordovician system.	Maquoketa series.	*Wykoff formation.*	14. Orthis bed.
			13. Leptæna bed.
		Maquoketa formation.	12. Orthoceras bed.
			11. Diplograptus bed.
		Transition formation.	10. Triplecia bed.
	Galena series.	*Galena formation.*	9. Maclurea bed.
			8. Lingulelasma bed.
			7. Camarella bed.
			6. Orthisina bed.
		Beloit formation.	5. Fucoid bed.
			4. Stictopora bed.
			3. Stictoporella bed.
			2. Bellerophon bed.
			1. Buff limestone bed.
	Saint Peter sandstone (Chazy), 150 feet.		
	Shakopee (Upper Calciferous), 50 feet.		

ignated formations, and the latter are, further, only the demarcations between beds which are more constant than others. The beds, which are the smallest divisions that it has been found practicable to designate, are not merely subdivisions of the formations and series, but are themselves nearly co-ordinate units of the entire succession of deposits, that are composed in the five formations, or two series. And if a detailed description of the parts of the entire succession is to be given, the beds have each to be described in preference to the formations. In truth the correlation and delimitation of formational divisions have been practicable mainly through the knowledge obtained from a study of the subdivisions.

They form a more or less interrupted series of deposits that are predominatingly transitional, the one to the other, but in part alternatingly follow one another. Regarding the single beds, they may be uniform from bottom to top, or composed of transitional series of strata or of alternating ones, they may be strikingly uniform in characters throughout the entire area, as for example, the dolomitic limestone at the base and the one at the top of the Galena series, or their sedimentary and to a less or greater degree the faunal characters change gradually between localities. The beds vary alike or unlike from place to place. Here and there the existence of any lithologic division remains doubtful, and if at the same place faunal evidence also fails a demarcation is locally impracticable. Particularly where the alterations have obtained that produced the typical Galena limestone phase, much difficulty is experienced.

No one bed is faunally distinct from the next one, but is distinguishable by some peculiar association of fossils. Some beds have one or more abundant species that are peculiar to it, others are characterized by the association of two or more, as for example the brachiopods. *Orthis subæquata* Con., which ranges from beds one to five inclusive, and *Rhynchonella increbescens* Hall, sensu stricto, which ranges from five to eight inclusive, are associated only in bed number five. Besides data derived in that way from the distribution of species, others are to be taken from the minute evolutionary changes of species. The writer has been fond of using data of the latter class, but it will not be practicable to give them in connection with the stratigraphic descriptions because they entail too much discussion to permit of their insertion here.

For the study of both migratory and evolutionary history of the species the division into formations is of less value than that into beds, because detail is essential. And since the purpose of the writer as paleontologist is primarily to establish a complete and uniform scheme of classification of the Galena and Maquoketa series for further use in the study of the organic remains and the conditions under which the abundant fauna of these deposits lived, detailed descriptions of the beds will be undertaken. An earlier attempt* toward that end is now repeated in part but in corrected and more complete form. The average thickness of some of the beds as given is emended, the Zygospira bed is included in the Orthisina bed, and the new name, Triplecia bed, stands for that which was before erroneously called Maquoketa shales, and the true Maquoketa formation is placed where it belongs. In the section near Spring Valley, Minnesota, the true Maquoketa formation is wanting between the Triplecia bed and Wykoff beds, and hence the mistake, for, having found the fauna of the Orthoceras bed in some small isolated exposures several miles farther south, it was supposed to belong to an upper Wykoff bed because it did not belong to the known section, while clearly belonging near the same. This mistake has remained already too long uncorrected, and strangely other writers have independently fallen into the same error.

1. BUFF LIMESTONE BED.

The Buff (Lower Buff) limestone lies conformably upon the Saint Peter sandstone, from which it is separated generally by an abrupt transition from sand to clay or shale. The clay stratum, three feet or less in thickness, is apparently an altered portion of the regular limestone and contains Buff limestone fossils only. When wanting, an impure sandstone belonging to the Saint Peter may seem to take its place.

The limestone bed itself is heavily and regularly stratified.

The lamination, when evident, is irregularly lenticular, from uneven distribution of impurities.† The stone is then very little dolomitic. In many localities the lamination has been nearly all obscured by alteration and a porous, more dolomitic limestone, or in other cases, a compact crystalline limestone has resulted. In the last named condition the fossils are inseparable from the matrix. When dolomitization has taken place, then too few fossils remain. Normally, however, large numbers are found in some laminæ, in the upper and middle part, besides scattered ones throughout. The latter are the less often wanting in altered strata.

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*Bull. Minn. Acad. Nat. Sci., vol. III, p. 319.

†See Bull. Minn. Acad. Nat. Sci., vol. III, p. 119, and pl. 1, fig. 1, C. W. Hall (1889).

The bed is sometimes 23 feet thick, or when reduced, 18 feet. Again the limestone is 15 feet or less, not including two to four feet of clay at the base. The maximum thickness is probably the primitive one. The stratigraphic position, the coarser structure and one species of fossil, *Rhynchonella orientalis* Bill., may be cited as means for determining this bed.

2. BELLEROPHON BED.

The new name, Bellerophon bed, is proposed here for the strata included under the name "glass rock" in southwestern Wisconsin. It is the lower half of the Lower Blue limestone.

The lowest stratum is argillaceous, breaks with a conchoidal fracture and crumbles when exposed to the weather, and thus forms in most cases an easily recognized contrast to the Buff limestone. The rest of the bed is more difficult to distinguish by lithologic characters alone. It is, however, more uniform and of finer texture than the Buff limestone, besides containing more fossils which commonly make up interspersed laminæ in the rock. The bed is about 12 feet thick at Minneapolis, Minn., but has been vertically compressed. The equivalent strata in Wisconsin are 15 feet thick.

The standard of thickness is rarely deceptive. Local alterations of the limestone itself are common. The numerous faunal peculiarities, on the contrary, are nearly uniform, although difficult to distinguish for they are small. *Bellerophon wisconsensis* Whitf. has not been found except in this bed, and although not abundant is still widely distributed. *B. bilobatus* Sow. is very abundant in the lower half, but appears to be totally wanting in the upper half. A lithologic division were also perhaps practicable.

3. STICTOPORELLA BED.

The upper half of the Lower Blue limestone of southeastern Wisconsin is elsewhere not simply a limestone. At Minneapolis, Minn., carbonaceous, dark brown or gray crystalline limestone forms the lower part of the bed in main, while intercalated clay and shale laminæ at the base become thicker upwards and form the main part of the upper strata. The bed is less than half limestone. Toward the southeast the amount of calcareous material is found to increase finally to the exclusion of the shale. At Decorah and McGregor, Iowa, the limestone far exceeds the marly constituents. At Lancaster and at Platteville, Wisconsin, some clayey shale still is found; at Janesville, none.

The shale laminæ are not uniform, neither are the limestone strata, in any locality, but the one encroaches upon the other alternately. The characteristic fossils, *Stictoporella frondifera* Ulr., associated with *Rhynchonella ainsliei* N. H. W., characterize the shaley portions. The limestones are often deeply carbonaceous, and deeper coloring of iron distinguishes them from the lower and next higher strata nearly everywhere.

4. STICTOPORA BED.

At Saint Paul, Minnesota, this bed is found thirty feet thick and consists of green clay, with a few thin strata of limestone that is made up of fossils. It is marked off from the bed below it by the contrasted purity of the clay and by the absence of certain species of fossils. The top is separated from the next bed along the undulating upper surface of a stratum of limestone.

The Stictopora bed is seldom well exposed in Minnesota, but is known to exist in Goodhue, Olmsted and Fillmore counties, like at Saint Paul, but with fewer limestone strata. At Decorah, Iowa, it is exposed on the north side of the river, 15 feet, and is probably 20 feet or more thick, but contains no limestone and scarcely any fossils. At Lancaster, Wis., shale at the base gradates to limestone with marl laminæ in the upper part of the bed. Farther east and south in Wisconsin, carbonaceous or crystalline limestone with brachiopod shells preserved, as at Platteville, or heavily bedded dolomitic limestone, as at Dodgeville, or limestone in irregular strata, with shaley lamina, as at Beloit, are local alterations of the limestone strata that there form this bed.

The thickness of the "Upper Buff" bed at Beloit, Wis., has been estimated at 55 feet,* but is probably much less. The estimate is difficult to verify. The thickness is as follows: Saint Paul, 30 feet; Fillmore Co., Minn., 25 feet or more; Decorah, Iowa, 20 feet or more; Dodgeville, Wis., 30 feet; Beloit, 35 feet; Rockton, Ills., 35 feet.

The name Stictopora bed was given by me from *Stictopora mutabilis* Ulr. Mr. Ulrich has since then changed the generic name to *Rhinidictya*† and has recognized the bed under the changed name, "Rhinidictya bed,"‡ an unnecessary correction.

5. FUCOID BED.

At St. Paul, Minn., the Fucoid bed is 18 feet thick and consists of fossiliferous shaley clay. Twiglike fucoids or sponges are numerous even at the base and make up more of each successive stratum until at the top of the bed a solid mass of them obtains. A few thin strata of fine-grained, heavy limestone are intercalated, and near the top are laminæ with oolitic limonite. The latter occurs as deep as to the base of the bed in northwestern Wisconsin. It is found southward as far as Fillmore county, Minnesota.

The shaley clay full of 'fucoids' at Saint Paul, becomes more and more calcareous and the fucoids fewer towards the south and southeast. In Goodhue county it is very fossiliferous but is not well exposed. The same is true in Olmsted and Fillmore counties, where this bed seems to be thinner, although of that one is not certain because the line of springs is along its top and local stratigraphic changes are probable in all known exposures. At Decorah, Iowa, it shows alteration by water which has carried away parts of the calcareous strata leaving a marl full of calcareous lumps and of fossils. `*Lingulæ* show a vertical compression of 0.1 to 0.2 of their length. This bed is seen exposed 15 feet thick here and may be 20 feet in all. 'Fucoids' occur at this locality at the base of the bed. At McGregor, Iowa, and at Lancaster, Wisconsin, a shaley limestone with few 'fucoids' represents it. At Dodgeville it is changed to a porous dolomitic limestone, not easily separable from the Galena beds. At Rockton, Ill., part of this bed is quarried, and at Beloit, Wis., that part of the "Upper Buff Limestone" that contains *Chætetes lycoperdon* auct. (*Prasopora contigua* Ulr. etc.,) is of this bed.

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*T. C. Chamberlin, Geology of Wisconsin, vol. II, p. 295 and 297.

†Vol. III, Final rep. Geol. Nat. Hist. Survey of Minnesota, p. 125.

‡Extr. 19th Ann. rep. Geol. Nat. Hist. Survey of Minnesota, p. 212.

The association together of *Plectambonitis sericea* Sow., *Orthis subæquata* Con., *Rhynchonella increbescens* Hall (*R. inæquevalvis* C.) and large *Prasopora*, is peculiar to the Fucoid bed.

6. ORTHISINA BED.

About 40 feet of strata are included in this bed. At Saint Paul, Minnesota, 20 feet can be seen in place. The first 8 feet of it I formerly called Zygospira bed, but the same falls, as now known, truly within the zone of *Orthisina americana* Whitf. and is otherwise not separable throughout. Both at Saint Paul and at Kenyon, Minnesota, the Orthisina bed is like the Fucoid bed at Decorah, Iowa, in that it is changed, probably recently, by water percolation until clay with rounded calcareous lumps represents most strata. Less changed limestone strata and a few compact limestone laminæ form the rest of the bed. At Saint Paul there are some calcareous oolite and fine ripple marks. At Kenyon one finds manganese nodules associated with polished, blackened and perforated surfaces of some limestone strata.

In Olmsted and Fillmore counties this bed is a shaley limestone. At Decorah, Iowa, it is firm, gray limestone. The quarries at Oshkosh, in eastern Wisconsin. are in this bed. Elsewhere in that state the bed forms a part of the typical, cavernous Galena limestone in which few fossils remain, so that complete demarcation of this and the next succeeding it is rarely possible, and is not needed. In this bed is *Orthisina* (*Clitambonites*) *americana* Whitf., and *Plectambonites minnesotensis* Sar. begins at its base.

7. CAMARELLA BED.

Upon the Orthisina bed follow strata of shaley, sometimes carbonaceous limestone, which, however, is not so shaley as the underlying bed in the same section. These strata are comparatively unfossiliferous as a rule. but crinoidal limestone, brachiopod strata and fossils in large numbers do occur. The species known from this section have been found to occur in the beds next lower and higher, and, like the Stictopora bed (4), this one is characterized more by the absence than the presence of peculiar species. *Strophomena trilobata* Owen ranges from this bed upwards, and *Zygospira uphami* W. and S., is abundant near Wykoff, Minnesota.

At Kenyon, Mantorville, near Pleasant Grove, and at Wykoff, Minnesota, exposures indicate a thickness in all not exceeding 30 feet. In

Iowa and Wisconsin a delimitation of this bed has not been attempted, from lack of suitable observed exposures with fossils to distinguish it.

8. LINGULELASMA* BED.

This bed is partly extant in Goodhue county, Minnesota, but better exposures are found at Concord, Wassioja and Mantorville in Dodge county, and on section 26 High Forest, Olmsted county, and near Wykoff, Fillmore county, Minnesota. The thickness is between 30 and 35 feet, and the contacts are not difficult to distinguish, as a rule, between this one and the Camerella and Maclurea beds. The Lingulelasma bed affords a firm limestone, less shaley than the one beneath it and finer grained than the one upon it. The upper strata are highly fossiliferous. At Dubuque, Iowa, the same is easily recognizable. *Lingulelasma galenensis* W. and S. is not abundant and occurs moreover also in the Fucoid bed (5) in Iowa. *Lingula hurlbuti* N. H. W., *Camarella owatonnensis* Sar. and *Plectambonites gibbosa* W. & S., belong to the Lingulelasma bed.

9. MACLUREA BED.

Species of *Maclurea* are found in beds of the Beloit formation, but not the very large specimens, *M. cuneata* Whitf., which are everywhere characteristic of this bed of coarse, porous, dolomitic limestone at the top of the Galena formation. In all known exposures of the Maclurea bed the rock shows alteration, such that internal casts of shells are distorted or re-imbedded in the matrix, and few fossils except large ones are preserved. The thickness is about 35 feet. Good exposures are at Wasioja and Stewartville, Dodge county, near Wykoff, Fillmore county, Minnesota, near Decorah and at Dubuque, Iowa.

10. TRIPLECIA BED.

This name is to include what was called Maquoketa shales in my former description. It is the top 30 feet of the "Galena formation" at Scales Mound, Illinois, and Dubuque, Iowa. At the latter place, the contact with the Maclurea bed can be seen. Here the Triplecia bed has the thinner strata which same also have shale laminæ between them. Between Conover and Decorah, Iowa, an exposure shows very much more shale than in the first mentioned localities. At Florenceville, Iowa, the contact with the Maclurea bed is again exposed and the crinoidal limestone in irregular strata with shale partings there seen is characteristic. The middle and upper strata may be seen near by at Granger, Minn., where carbonaceous and argillaceous shale predominates in the middle portion and an impure, browinish-gray limestone forms the top. The faunal characters place this bed in the Maquoketa series. *Triplecia ulrichi* W. and S., *Plectambonites præcosa* Sar. are peculiar to this bed and *Orthis subquadrata* H. with *O. kankakensis* McChes. are found too.

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*For the spelling of this word see S. A. Miller, North American Geology and Palæontology, Appendix, p. 689.

11. DIPLOGRAPTUS BED.

Between the Triplecia bed and the Diplograptus bed there is a well marked stratigraphic change and one finds the irregular strata of the former contrasted by the uniform laminæ of the latter, except where concretionary structure has disturbed it. The change is not always from more calcareous strata to less calcareous ones as at Graf, Iowa, and vicinity, but farther north is nearly the reverse as at Granger, Minnesota, where the Diplograptus bed is a brown carbonaceous limestone underlain by shaley strata of the Triplecia bed.

The fauna is meagre in both phases of this bed and local in character. Three species of *Asaphus*, *Bellerophon bilobatus* Sow., *Cyrtolites ornatus*, *Conularia*, and *Diplograptus* are found in the limestone, and in the clay shale farther south are the last named with species of *Lingula*. Not one species is peculiar to this bed. At Dubuque, Iowa, and at Scales Mound, Illinois, one finds thousands of small fossils in a fine calcareous gravel that forms two or more thin strata near the base of the shales. They are secondary fossils and do not belong to the fauna of this time, but are evidently from the next older beds, having been torn from their matrix and transported, as the rolled and worn condition of the shells and interior casts shows. There are lacking among them many species from the next older beds of the locality, which would have been as easily transported as they, and hence they must have come a long distance from where local conditions had produced a difference in fauna.

The limestone in northern Iowa is 20 feet thick, and the clay shale equivalent at Graf, Iowa, is about the same, the division line there being referred to a position close below the calcareous layers in which the *Orthoceras* are found.

12. ORTHOCERAS BED.

At the north boundary of Iowa, in Howard county, this bed is of limestone 25 or more feet thick, that contains numerous quartz concretions and silicified fossils, and that breaks up in its natural exposures into small cubical blocks much more than into slabs. It thins out northward or at least it is traceable only a few miles, beyond which the next higher bed (13) rests directly upon the Triplecia bed (10). Southward as at Elgin, Iowa, it is 45 feet thick and is more shaley. From thence, it has not been traced continuously to Graf, Iowa, but at that place an exposure, as well known, exists and in it 20 feet of this and part of the next lower bed are seen. At that place the limestone is reduced to a few mainly very fossiliferous strata between which are carbonaceous clay-shale deposits. At Scales Mound, Illinois, the shale is almost without limestone.

The fauna is not more constant than the sedimentary characters. In the limestones there are *Orthis emacerata* H., *Murchisonia milleri* H., *Ctenodonta calvini* Ulr., *Cleidophorous* sp., *Orthoceras*, *Cyrtoceras*, and in the shales are linguloid shells and *Diplograptus* mainly, besides some small fossils that appear to be secondary. The fauna of this bed should be easily recognizable to the geologist as not Galena (Trenton) for even in the well known trilobite bed at Elgin, Iowa, where the fossils are a few species only, one finds *Orthis kankakensis* McChes., *O. emacerata* H., *O. insculpta* H. and others that are no other than Maquoketa (Hudson) fossils. But in this bed as in the Diplograptus bed, *Orthis subquadrata* H. and *Strophomena trilobata* Owen (*S. flexuosa* Bill.) and perhaps for that reason it has been mistaken for "Trenton."

13. LEPTÆNA BED.

The succession of small exposures that are found along the railway west of Wykoff, Minn., represent about 30 feet of fine-grained, soft limestone that there composes this bed. In some strata fossils are very numerous, often silicified, but are not accompanied by quartz concretions. Near the Iowa and Minnesota boundary, by Granger and Florenceville, it is found with the next lower bed often in one contiguous exposure. It is distinguished from the Orthoceras bed by the manner of weathering into slabs instead of into blocks, and likewise by a faunal change. Near Postville, west of Elgin and near Eldorado, Iowa, it is to be seen and is fully 75 feet thick, consisting of limestone at the top and of lime and clay or chiefly clay in the middle or lower portions. At the base there is a sudden transition to the purer limestone of the Orthoceras bed.

Farther south it has not been observed, except that there is a great bed of unfossiliferous, impure clay, evidently extant in its supposed position at Graf, Iowa. East of Scales Mound, Illinois, a very impure limestone, seen 20 feet, is probably the same, but there were found two species of trilobites (Asaphus) only and they are common to all beds of the Maquoketa series, hence it is not certain that the strata in question do not belong to the Orthoceras bed. At Graf, Iowa, and northward no fossils were found until reaching Elgin, but thence northward to where the bed is entirely removed in southern Minnesota fossils are more abundant, some strata near the top being full of them.

Orthis subquadrata H., *Plectambonites recedens* (Sar.) and *Rhynchonella perlamellosa* Whitf., are very abundant in the limestone: the first is known only from this and the Triplecia bed (10), the other two in this and the succeeding bed only. Species of *Leptæna* are most abundant.

An interesting fauna is found at Wilmington, Illinois, in shales close below the Niagara limestone, and it is evidently the equivalent of this bed, or possibly of the next one.

14. ORTHIS BED.

Upon the Leptæna bed at Spring Valley, Minn., near the type exposures of that limestone, there is found in many exposures a bed of mixed lime, clay and quartz sand in different proportions in different strata. The bed in this locality is subject to flooding by water that pours out of the crevices in rainy seasons, so that one can not rely upon the condition of the strata as positively primitive, but some sandstone strata with fine mud-covered upper faces that are here found are possibly proof of a litoral deposit. There are very few fossils, and in the upper part, which is an easily disintegrated marl, one finds none. The few known fossils here appear to be secondary, and one would not be able to say that this is not a part of the immediately superimposed Devonian were the bed not traceable southward.

The base of the bed is a quartz and lime sandstone of coarse texture. Nearly the same strata are to be seen two miles west of Granger, Minn., on the state boundary by the road, but nowhere does a complete section of the bed come to view, and but few fossils are found. Near Eldorado, a few miles west of Elgin, Iowa, 75 feet of clay with fine sand intermixed* is seen in place between the Leptæna bed and the Niagara limestone. Near Brainerd there is an interlaminated fossil limestone and clay of varying thickness, from zero to six feet, which in part fills up depressions on the undulating surface of the sandy clay. One finds the same along the railway one mile west of Kidder, Iowa, and fossils from it are found at Graf, and are reported from near Shullsburg, Wisconsin.

The clay and limestone top is exceedingly fossiliferous, but the species in it are not different apparently from the few poorly preserved ones from the main body of the bed. I therefore regard it as one of the lenticular fossil strata that may be found likewise deeper down in the bed like the one in this bed at Iron Ridge, Wisconsin.

The Orthis bed is much less sandy at Graf, Iowa, than at Eldorado, and perhaps not so thick, but regarding the thickness there are no reliable data to be had except that there is room for very many more strata between the Galena and Niagara formations than have been supposed. The Maquoketa series is nearer 200 feet than 80 at Graf.

In this bed are *Orthis occidentalis* H. and the typical *Leptæna unicostata* M. and W. with *Rhynchonella anticostiensis* Bill.

The top of this bed nearly always is variegated red, blue and yellow with iron. At Iron Ridge, Wisconsin, the "Clinton" iron ores rest upon it.

The above brief descriptions will, it is hoped, enable others to recognize the true relation of parts of the Galena and Maquoketa series. The descriptions are by far not complete, for but little attention could be given to analyses such as would be necessary for the determination of sedimentary and petrologic characters, and very much remains to be added in the way of exact measurements of the strata, as well as in that of tabulating the faunas. The beds described could no doubt be traced through northeastern Wisconsin, upper Michigan, St. Joseph's island, etc., and probably they may be recognized in part, at least, in Missouri, Kentucky and New York. What is lacking in this paper may be the subjects of others; what is presented is intended to enable geologists who are confined to restricted areas, to present their observations in such form that they may be of greater use in the study of the history belonging to the Galena and Maquoketa deposits and their faunas.

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*I am indebted to Mr. Grant Finch, principal of the high school at West Union, Iowa, for knowledge of this good exposure and others in that district.

The beds one and two have had nearly the same primitive sedimentary characters throughout, and their faunas are likewise uniform in areal distribution. Beds three to five are limestone in the south and east, but mainly clay of shallow water deposition to the northwest, and their faunas are found to be locally different, in part because of different degrees of preservation, in part because some species like *Orthis deflecta* Con., never existed except in the limestone areas. From the base of the Galena towards its top there is a gradual convergence back to a widely uniform condition. The bed No. 10, that forms the transition formation to the Maquoketa series is less lacking in uniformity than its outward appearance would indicate. The beds of the Maquoketa formation (11 and 12) have local phases in predominance and merely the dark, carbonaceous color is the widest noted character. The Maquoketa formation is intercalated into the series, so to say, and only towards the top, and more particularly in the succeeding Leptæna bed is there a return toward the characteristics of the bed (10) beneath it. In the last of the series of beds there is evidence that a shore was not far north of the Iowa and Minnesota state boundary. And the top of the bed in Iowa shows evidence of iron deposits, as it does notably in eastern Wisconsin. In Wisconsin, Illinois and Iowa the Niagara limestones, in southeastern Minnesota the Devonian rests upon the Maquoketa series, there being thus a varying interval of no deposit following it.

One cannot fail to note the large numbers of Trenton and Hudson species of fossils that are found in the Galena and Maquoketa respectively, but there are instructive differences, such as the continuance of the Trenton form of *Orthis (Platystrophia) biforata* from bed No. 5 through both Galena and Maquoketa series, the Hudson "varieties" *O. lynx*, *O. acutilirata* etc., not being found. Again the trilobite genus *Illænus* is strangely not represented in my collections from the Maquoketa series but is found in all beds of the Galena series.

For that same and for the range of the *Maclurea*, *Receptaculites* et al. we have not sufficiently full explanation. To understand the history of the physical changes and faunal migrations in this area, will no doubt be the surest means for explaining in a satisfactory manner the relations to the type Trenton and Hudson. For the present, correlations into districts into which we cannot trace the beds by stratigraphic continuity, are to be assumed with caution, prompted by our knowledge that quite recently we have not been entirely successful in correlating not distantly separated sections of the Galena and Maquoketa series by the lithological and paleontological methods.

RULES AND MISRULES IN STRATIGRAPHIC CLASSIFICATION.

By Jules Marcou, Cambridge, Mass.

I.

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Giraud-Soulavie.—William Smith.—Alexandre Brongniart.

At first the great stratigraphic classifications were made according to some great area of geological distribution of rocks having the same petrography, or at least having a certain similitude as regard the lithology and the colors of the main strata; such as the chalk, the Red Sandstone, the Jura limestone, the slate, the carbon or coal. Great breaks and discordance of stratification were also used, as well as transgression and retrogression of the strata. And according to those simple and most striking rules easily recognized in practical geology, the strata were divided into the Primary, the Transition, the Secondary, and the Tertiary periods or great systems, and into the Grauwake, the Old Red sandstone, the Carboniferous, the New Red sandstone, the Lias, the Jura limestone, the Cretaceous, the Calcaire grossier, etc.

Then came the "medals of creation," or fossil organic remains. The first who recognized that fossils differed according to their age and the superposition of the strata in which they are found was the French abbé. Giraud-Soulavie, who in 1777 published this new principle in his works on the south of France, and particularly on the geology of Vivarais. (*Histoire naturelle de la France Méridionale*, 7 vol. 8vo, Paris, 1780-1784. The Chapter VIII, in the first part, containing the chronology of fossil animals, according to the strata in which they are found, was written in 1777, and read before the Academy of Sciences of Paris, the 14th August, 1779.)

Without knowing the researches and discoveries of the abbé Giraud-Soulavie, William Smith, in England, from 1794 to 1799, derived identical principles; and in 1799 he wrote a tabular view entitled. "Order of the strata and their imbedded *organic remains* in the vicinity of Bath, examined and proved prior to 1799," which, although it remained manuscript until 1844, was copied and largely circulated among English geologists. It was not until 1815 that *Strata Smith*, as he is called, was able to issue his "Geological map of England and Wales, with part of Scotland"; and only in 1817, 1818 and 1819 that finally he published his two works, "A stratigraphical system of organized fossils," and "Strata identified by organized fossils."

Curiously enough, both Cuvier and Alexandre Brongniart did not know the discovery of Giraud-Soulavie, a Frenchman like them, nor of William Smith; and in their studies of the Paris basin they came to the same conclusion, of strata identified by organized fossil remains—a remarkable coincidence, which, although the question of priority is unquestionably in favor of Giraud-Soulavie, shows that the progress of knowledge of strata and fossil remains had arrived at that period when a new and most important step was to be taken.

Cuvier and Brongniart came at a most opportune moment; and their capital work, "Essai sur la géographie minéralogique des environs de Paris," written and presented to the Council of Mines, in Paris, in 1807, was issued first in the *Journal des Mines*, 1808, and two years after as a separate volume in 4to, Paris, 1810. It is called by a brother geologist and a contemporary, J. J. d'Omalius d'Halloy, "l'ouvrage le plus capital de notre siècle (au point de vue de la géologie), puis qu'il contient le premier germe de la révolution qui a créé l'état actuel de cette science, c'est à dire, qui a appliqué la paléontologie à l'étude da l'écorce du globe terrestre."*

Brongniart pushed the discovery farther on and gave to the principle an extension, so great and so beneficial to progress, that after him little was left to establish the rule not only all over Europe, but to extend it to every continent and island in both hemispheres. It is in his memoir, "Sur les caractères zoologiques des formations, avec l'application de ces caractères à la détermination de quelques Terrains de Craie" (Extrait des *Annales des Mines*, 1821-22, Paris), in which we read at p. 9, "Je regarde donc les caractères d'*époque de formation* tirés de l'analogie des corps organisés, comme de première valeur en géognosie et comme devant l'emporter sur toutes les autres differences, quelques grandes qu'elles paraissent."

That paper of Alexandre Brongniart is so important and so little known on this side of the Atlantic, that I am induced to quote two other sentences: "Je ne prétends pas dire cependant que les caractères tirés de la position relative des couches, de leur nature (pétrographie) etc., ne doivent pas être employés, même avec confiance, par le géologue pour déterminer différentes époques de formation; seuls ou réunis avec ceux qu'on tire de la nature des corps organisés fossiles, ils ont la plus grande valeur; mais je pense seulement, et je crois avoir démontré de puissants motifs de cette opinion, que lorsque ces caractères sont en opposition avec ceux qu'on peut tirer de la présence des corps organisés fossiles, ces derniers doivent avoir la préférence." "Je ne dissimule pas qu' il faut apporter beaucoup d'attention et de ménagement dans l'emploi qu'on en fait. Je n'ignore pas qu' il faut savoir distinguer et évaluer même l'influence des distances horizontales ou des climats sur les différences spécifiques; qu' il faut savoir apprécier les ressemblances apparentes, quelquefois même réelles, que présentent dans des formations évidemment trés distinctes quelques espèces qui ont eu le privilège assez rare de survivre à la destruction de leurs contemporains, et de rester toujours les mêmes au milieu de tous les changemens qui se sont passés autour d'elles, etc." (*Loc. cit.* pp. 10 and 11.)

**Notice biographique sur Alexandre Brongniart*, lue à la séance du 19 Mars, 1860, de la Société géologique de France, p. 2, Paris.

So according to the author of the palæontological rule for determining and classifying strata, it must be used with a great deal of care, and much attention must always be paid to similar forms of fossils and even to a few identical species which enjoy the privilege to survive their contemporaries. Finally the horizontal distances or climats, as Brongniart says, exert an influence which ought to be carefully weighed.

Let us see how those rules have been applied in the classification of strata in North America and point out the misrules made which have kept back so persistently the progress of American geology.

CLASSIFICATION OF THE NIAGARA GROUP WITH THE OLD RED SANDSTONE.

The first important misrule in America is found in the *Second Annual Report*, Geological Survey of New York, p. 291, Albany, 1838, where the author of the report of the fourth geological district, after classifying the Niagara group with the Old Red sandstone of Europe, says: "The evidence for this conclusion rests, in part, upon the organic remains, and if we can rely on these characters there appears little question regarding the age and position of our rocks" So, according to the writer of the report, the Niagara group is to be classified as being above the Silurian system of Murchison, instead of being the main and central part of the Upper, or true Silurian, an erroneous correlation and classification due to palæontological mistake.

CLASSIFICATION OF THE TACONIC SYSTEM WITH THE HUDSON RIVER GROUP.

The second misrule by the same writer is even more important, for it suppressed a whole system, the greatest in regard to thickness of strata—about 25,000 feet—and the first link in the great chain of fossil remains which have existed on our globe. Here the mistake was made by the wrong determination of fossils, mainly trilobites, and a no less erroneous idea of wrong stratigraphy and wrong lithology, almost incredible, for it was made not only against all the rules of stratigraphic classification, but against an exact description and classification of those strata made by the *Strata Smith* and Alex. Brongniart of North America, the late Dr. Ebenezer Emmons, who had called them the *Taconic system*, containing a special fauna. The result of that misrule was a complete stop of progress for the Lower Paleozoic rocks of North America from 1847 until 1860, and even many years after, notwithstanding the researches and publications not only of Emmons, but also of Barrande, Billings and the present writer.

The misrule adopted by the opponents of the Taconic system operates still; in a less degree, it is true, but it is sufficiently strong to create great confusion in the classification of those strata in the Appalachian region, New England, New York, Canada and western Newfoundland. In including Canada I do not mean the whole Canada Dominion, but only the old Canada or Province of Quebec; for in New Brunswick and Nova Scotia excellent and very remarkably good work of classification and correlation, based on exact palæontology and also on the stratigraphy, has been done by Mr. G. F. Matthew.

The mistakes are still so important and so numerous that it is necessary to see each case and point out how the rules of palæontological classification and correlation or equivalency, as well as the principles of stratigraphy and lithology have been violated and misused.

THE GEORGIA FORMATION OR *Elliptocephalus* (CALLED SOMETIMES *Olenellus*) ZONE.

After a study of the fossiliferous locality of Georgia, Vermont, and its vicinity, the present writer classified the Georgia formation with its characteristic *Elliptocephalus* (*Olenellus*) *thompsoni* as the upper part of the Middle Taconic (called by some Middle Cambrian, not of the original Cambrian of Sedgwick), and placed it above the St. John formation of New Brunswick, Massachusetts and Newfoundland, so well characterized palæontologically by its numerous and large *Paradoxides*. We must add, that the direct superposition of the beds containing *Elliptocephalus* (*Olenellus*) over the beds containing *Paradoxides* has not yet been found anywhere round Georgia, nor in the whole Appalachian and Quebec regions. The classification was made palæontologically; and one of the best and most exact palæontologists, the late S. W. Ford, did go so far as to show the embryologic relations of *Elliptocephalus* (*Olenellus*) with *Paradoxides*; *Elliptocephalus* being a metamorphosis and a descendant of *Paradoxides.*[*] Stratigraphically, at Swanton, the *Elliptocephalus* zone is in contact with the Phillipsburgh formation, and it is followed toward the Green mountain range east of St. Albans by a thick black shale formation, in which no fossils have yet been found.

Now comes one of those cases of exact determination of generic form, on which depend not only the correlation or equivalency of strata at great distance, but also the rule of stratigraphic classification. Below the zone of *Paradoxides* in Scandinavia, and in close contact with it, a fauna was found with a trilobite, which after being referred to *Paradoxides* was finally adjudged as belonging to the American genus *Elliptocephalus* (*Olenellus*). The result was that the Scandinavian geologists insisted on placing the *Elliptocephalus* (*Olenellus*) zone below the *Paradoxides* zone. However, a Swedish palæontologist of the first order, Mr. G. Holm, gave a detailed description of *Olenellus* (*Elliptocephalus*) *kjerulfi*, insisting on the differences existing between that species and the true *Elliptocephalus* (*Olenellus*) as well as the true *Paradoxides*; for him it was a new genus; but he did not go so far as to give a name to it. The learned palæontologist of St. John, Mr. G. F. Matthew, agreed entirely with Mr. Holm, and justly and most appropriately gave to that new genus of trilobite the name *Holmia*, in honor of Gerald Holm. As the other fossils accompanying *Holmia kjerulfi* are entirely different generically from those found at Georgia, the correlation of the two formations in Scandinavia and Vermont, is a mistake made by a palæontologic misrule, due to an erroneous determination of fossil remains.

Then came a most unfortunate interposition of the palæontologist of the United States Geological Survey. In August, 1888, Mr. C. D. Walcott, in looking over the stratigraphy of eastern Newfoundland, so well worked out by one of the Provincial geologists, Mr. J. P. Howley, found at Manuel's brook a new railroad cutting, showing a good, fresh section with well preserved fossils, and among them a trilobite which he classified as belonging to the genus *Elliptocephalus* (*Olenellus*), calling it *Olenellus bröggeri*. Against all palæontological rules established by Alexandre Brongniart, which demand similarity and even identity of forms of fossil animals to correlate one formation with another, the beds of eastern Newfoundland containing *Elliptocephalus* (*Olenellus*) *bröggeri*, were regarded as the equivalent of the Georgia beds of Vermont. The two faunas have absolutely nothing in common; on the contrary, the eastern Newfoundland fauna contains forms of fossils all older than the Georgia ones, for even the *Elliptocephalus* (*Olenellus*) is not an *Olenellus*, but a true *Holmia*.

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[*] Ford showed the mistake of referring the trilobites first described by Emmons as *Elliptocephalus asaphoides* to *Olenus*, in calling it *Olenellus*, when instead of being related to *Olenus* it is much more close to *Paradoxides*, reproducing in its embryology the form of a *Paradoxides*. In fact, the name so generally used lately ought to be dropped entirely, first, on question of priority, and second, on account of the mistake made in regard to all the European and eastern Newfoundland specimens, which do not belong to that genus, but are truly another genus, called by Mr. Matthew *Holmia*.

Following are the lists of Georgia and Manuel's brook, as given by the *Bulletin of the U. S. Geological Survey*, No. 81, at pp. 260-261 and 278. At Manuel's brook the fossils are: *Obolella atlantica*, *Hyolithellus micans*, *Helenia bella*, *Hyolithes princeps*, *H. impar*, *H. quadricostatus*, *H. similis*, *H. terranovicus*, *Scenella reticulata*, *Stenotheca rugosa*, varieties *acuta*, *costa*, *erecta*, *lævis*, and *pauper*, *Platyceras primævum*, *Microdiscus helena*, *M. speciosus*, *Olenellus* (*H.*) *bröggeri*, *Avalonia manuelensis*, *Agraulos* (*S.*) *strenuus* and var. *nasutus*, *Solenopleura bombifrons*, *S. harveyi* and *S. howleyi*.

At Parker's quarry, Georgia, the fossils are: *Palæophicus incipiens*, *P. congregatus*, *Diplograptus simplex*, *Climacograptus ? emmonsi*, *Kutorgina cingulata*, *Orthisina orientalis*, *O. festinata*, *O. transversa*, *Microdiscus parkeri*, *Mesonacis vermontana*, *Olenellus thompsoni*, *Oleniodes marcoui*, *Bathynotus holopyga*, *Ptychoparia adamsi*, *P. vulcanus*, *Protypus hitchcocki*, *P. senectus* and *P. senectus* var. *parvulus*, and it is impossible to account for the absolute difference in the two faunas, by the great distance, for the true Georgia formation, with its characteristic fossil, the *Elliptocephalus* (*Olenellus*) *thompsoni*, has been followed through the entire province of Quebec, as far as the peninsula of Gaspé, and even on the western, or French shore of Newfoundland, where a well-preserved head of *Elliptocephalus* (*Olenellus*) *thompsoni* was found by the late J. Richardson, of the geological survey of Canada.

Several papers, of a character rather sensational, were published here and also in Europe, by the palæontologist of the U. S. Geological Survey, and the result as stated, in the book: *Correlation papers—Cambrian*, "Bull. U. S. Geol. Survey," No. 81, p. 360, Washington, 1891–92, is the placing of the Georgia formation in the Lower Taconic (called by some Lower Cambrian), below the *Paradoxides* zone of St. John (New Brunswick), of eastern Newfoundland, and of Braintree (Massachusetts), which then is regarded as Middle Taconic (Middle Cambrian).

Several years have passed since the publication of the view and opinion, expressed with some emphasis and remarkable assurance, in the volume *Correlation papers—Cambrian;* and nothing has been found to sustain that classification; on the contrary, the best experts for trilobites in America consider the *Elliptocephalus* (*Olenellus*) *thompsoni* of Georgia as generically different from the *Olenellus bröggeri* of Manuel's brook. The latter probably is congeneric with *Olenellus kjerulfi*, of Scandinavia, and both species—*O. bröggeri* and *O. kjerulfi*—belong to the genus *Holmia*, entirely different from the genus *Elliptocephalus* (*Olenellus*) of Georgia. So we have an example of confusion in the classification and correlation of strata brought up by an erroneous determination of a generic group of trilobites.*

What a strange destiny for the Georgia trilobite; first, it was determined as an *Olenus* instead of an *Elliptocephalus* and placed stratigraphically on the top and consequently above the second fauna, instead of belonging to the primordial fauna; second, it was taken from the *Olenus* and called *Barrandia*, then afterward *Olenellus* and considered as a Potsdam fossil, that is to say, placed at the summit of the Upper Cambrian. Finally it was placed at the bottom of the Lower Cambrian, running a race through 25,000 feet of strata and two great geological epochs of the earth. And now it is restored to its exact place, in the upper part of the Middle Taconic (Middle Cambrian).

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*The present writer pointed out the mistake in referring the Newfoundland trilobite to *Olenellus* instead of the genus *Holmia*, as soon as it was published ("The Lower and Middle Taconic of Europe and North America, 1890"), and recalled it in his paper of 1892: "The Geological map of the U. S., and the U. S. Geological Survey," p. 53, but to no purpose, so far as it concerned the U. S. Geological Survey.

THE PHILLIPSBURGH AND POINTE LEVIS FORMATION.

We come now to the second misrule in the classification of strata belonging to the lower Palæozoic rocks. Dr. Emmons recognized below the Calciferous group the Potsdam sandstone, which according to his observations is the bottom group of the Champlain division; and below the Potsdam he saw an enormous series of strata, 25,000 feet thick, mainly slates, which he called most appropriately the Taconic system. At different levels in that system Emmons found magnesian limestone, some of which he called Stockbridge limestone, or marble, of Berkshire county.

He was confronted with a stratigraphic anomaly, which astonished him considerably, finding now and then a limited deposit of limestone, generally more or less magnesian, but sometimes of pure or even marly limestone. These deposits, he thought, were pockets of more recent limestone deposited in holes of the slates (Taconic slates) and belonging, according to a few fossils collected at different localities, to the Calciferous group, or to the Chazy and Black River divisions, or even to the Trenton limestone. Dr. Emmons maintained that there was a well marked discordance of stratification between those beds of pocket limestones and the Taconic slates surrounding them. It is true that a sort of unconformity, or, more exactly, of diffuse stratification exists between the slates and the small islets of limestone, due to the structural nature of these islets, which I admit are rather puzzling and difficult to account for. The first time I came in full view of some of them round St. Albans, Vermont, in 1861, I had no difficulty to see that they were lenticular masses of magnesian limestone, deposited at the same moment and inclosed in the slates, and consequently contemporary with the slates. But at Phillipsburgh, Canada, those islets of limestone are so numerous and so elongated as to present—at first sight—the aspect of a regular deposit of limestone analogous to the deposits of the Chazy limestone at Chazy village. It was when working out the stratigraphy of Pointe Lévis, opposite Quebec, in 1861 and 1862, that at last I became convinced that all those outcrops of limestone were inclosed in the slates and of the same age as those slates, and that the fossils found, now and then, in some of those limestone islets, instead of indicating that the age of some was Calciferous, others Chazy, others Black River and others even Trenton, belonged to a special fauna, older than the second fauna or Champlain division of Dr. Emmons; they are in company with forms recalling the primordial fauna or true Taconic, but are new forms which developed completely only in the period of the second fauna proper and were found at Pointe Lévis and Phillipsburgh, only in a sporadic state without the great development they attained during the deposits of the strata of the second fauna. In one word, we have in some of those limestone islets the phenomena of *colonies*, as defined by Barrande. After careful surveys at Pointe Lévis, Quebec city, Phillipsburgh, Highgate-fall, Highgate Springs, Swanton and St. Albans' bay it was evident that we have there directly in contact and in perfect stratigraphic conformity with the Georgia formation a mass of strata, mainly black slates, of a thickness at least of 5,000 feet, containing now and then lenticular masses or islets of limestone, sometimes very numerous and forming large massifs like that at Phillipsburgh and Shoreham, and at other times very limited and even disappearing entirely.

That mass of black slates, with lenticular masses of limestone, can be divided, on palæontological ground, into two parts, the lower one containing at Pointe Lévis quite a large number of primordial fossils belonging to the following genera: *Dikelocephalus*, *Conocephalites* (*Ptychoparia*), *Menocephalus*, *Agnostus* and *Metoptoma*, mixed with special forms of marine animals entirely unknown in the typical second fauna of the state of New York and Canada, namely: *Bathyurus*, *Bathyurellus*, *Remopleurites*; and finally a certain number of forms which developed fully during the second fauna, and are found in the Taconic black slates, only in a sporadic state, being always rather rare, such as *Illænus*, *Ampyx*, *Cheirurus*, *Asaphus*, *Amphion* and *Harpes*. Brachiopoda, Gasteropoda and Cephalopoda, as well as graptolites are also numerous at different levels of that group of strata; but the species are generally confined to the Upper Taconic, and only very few of them pass into the rocks of the second fauna proper or Champlain system (Lower Silurian of some or Ordovician of others). In fact, we have in America the same phenomenon of mixture of forms of the primordial and second faunas as exists in Wales, and in England in the Tremadoc group and the Arenig or Skiddau group, and at Hoff in Bavaria. It is important to recall that the Geological Survey of Great Britain, conducted by Sir Andrew C. Ramsay, found during 1875 that fossils passed from the Tremadoc into the Arenig, ten or eleven species, according to Etheridge, the palæontologist of the survey, and that between the Arenig and the Caradoc beds (true Ordovician or second fauna) eight species also passed, showing beyond any doubt that species are no more immutable in their position of strata in Europe than in America.

As far back as 1862, the present writer divided the Upper Taconic into three parts, calling the lower part Pointe Lévis or Phillipsburgh group, with a thickness of 3,000 feet; then the middle part called Swanton slates or City of Quebec group, thickness, 2,400 feet; and finally the Potsdam sandstone, three hundred feet. Everything published since, by friends and opponents of the Taconic system, has proved the fitness and value of that definition; only it is very hard for those who are accustomed to call Calciferous formation, Chazy, Black River, Trenton, and Hudson River groups, all the outcrops of some islets isolated among the black slates of the Taconic, containing a few fossils, recalling, in a small scale, those formations, to accept their mistake, preferring to pass over and neglect all stratigraphical, lithological and even palæontological rules. Of course they are involved in an ocean of difficulties, but nothing stops them, and they hope, with proper use of faults—even when faults cannot be seen—and different facies and thickness of formations to explain, satisfactorily at least to themselves, that the Phillipsburgh series belongs to the Calciferous formation and the Quebec City or Swanton slate series, in part, to the Chazy, Black River, and Trenton, and even in some part to the Hudson River (Utica and Lorraine shales), the most heterogenous mixture and chaotic classification that it is possible to imagine. Some quotations of some of the last classification used by some observers, will give an idea of the confusion brought about by misrules.

Geology of Chazy Village.

The classification of the Champlain division—called first by Sedgwick Cambrian and afterward Upper Cambrian, and by some Lower Silurian and Ordovician—was made by Dr. E. Emmons, and a full description given by him in his final *Report of the Second District of the Geological Survey of New York*, pp. 102-122, Albany, 1842. The village of Chazy with its environs on lake Champlain was taken as a typical place for the section, and many geologists have been there since, visiting and studying the fine section, showing all the strata from the Potsdam sandstone to the Utica slates. Here is a résumé of the section as I took it on several occasions, extending from 1849 to 1863. In discordance on the Potsdam—southwest of the village of Chazy—we see about 250 feet of Calciferous sandrock, containing only four or five species of fossils, such as *Orthis*, *Strophomena*, *Scalites* and numerous fragments of crinoids.

Above it we have the Chazy limestone; about two hundred feet in thickness, containing a quantity of fossils, such as *Maclurea magna*, *Bellerophon*, *Asaphus*, *Stenopora*, *Orthoceras*, *Rhynchonella*, crinoids, stems, etc.

Then come the Birdseye limestone and Black River formation, called also Black Marble of Isle la Motte; thickness about forty feet, containing fossils belonging to *Isotelus*, *Orthoceras*, *Maclurea*, *Leptæna*, etc.

Above it we have a fine development of a blue limestone, known as the Trenton limestone, four hundred feet thick, containing a very large number of fossils such as fragments of the large *Isotelus gigas*, *Calymene*, *Trinucleus*, *Enomphalus*, *Murchisonia*, *Avicula*, *Bellerophon*, *Orthis*, *Leptæna*, *Athrypa*, etc.

Finally, we have resting on the Trenton the Utica slates and Lorraine shales, with a thickness of about two hundred feet, containing in great abundance *Triarthrus beckii* on the shores of the lake at Rouse's Point and all over the Alburgh peninsula.

Tabular View of the Champlain system at Chazy and Vicinity.

Utica and Lorraine slates and shales	200	feet
Trenton Limestone	400	"
Black River and Birdseye Limestone	40	"
Chazy Limestone	200	"
Calciferous Sandrock	250	"

The same system of strata, with the same composition and the same characteristic fossils, extends interruptedly from Chazy to Rouse's Point, St. Jean and Montreal, and covers the greatest part of Jefferson county, state of New York, on the right shore of the St. Lawrence river and at the end of lake Ontario, and is followed without interruption through the state of New York as far as the Mohawk valley.

During many years the referring of the Phillipsburgh and Pointe-Lévis group and the Swanton and Quebec city group, as defined by me in 1862, to the Calciferous and Utica-Lorrain (or Hudson group) was rather a simple theoretical formula used by my critics to mean only that they considered it impossible to refer those strata to any horizon below the Potsdam, on account of some of the fossils found in them. At the same time there was a reluctance to question either the exactness of the determination of those fossils or of their scientific value in classification of strata. They were spoken of as matter of facts, not requiring descriptions and illustration by figures of those on which such a correlation with the Calciferous and the Hudson was based: a sort of authoritative synchronism imposed as a creed in American and Canadian stratigraphy. Eight or ten, a dozen at most, of fossils —just the same number of species signalized by Andrew Ramsay and Etheridge as passing from the Tremadoc and Arenig divisions into the Caradoc group in Wales and England— some fossils badly determined as the *Atops trilineatus* wrongly referred to as *Triarthrus beckii*, the *Microdiscus* considered as a *Trinucleus*, and some Brachiopoda, an order of fossils more apt to possess forms which pass from one system to another, are the only true base made use of; a very narrow and incorrect view of the palæontological characters established by Alexandre Brongniart.

But since 1888 attempts have been repeatedly made to put practically in the tabular view of the Champlain system the six or eight thousand feet of strata, called and limited by me as the Phillipsburgh and Pointe-Lévis group and the Swanton and Quebec City group; and curiously enough, although those two great groups at the typical places—the vicinity of Quebec city and the vicinity of Phillipsburgh and Swanton—succeed one another in concordance of stratification, one is placed as

Calciferous at the base of the Champlain system and the other at the very top of that system as superior to the classical Utica-Lorrain division. The process employed, if accepted, will break all the rules of stratigraphic classification, replacing well observed facts by hypotheses.

In 1888 appeared a paper entitled, "The Original Chazy Rocks" (Amer. Geologist, vol. 2, No. 5, November), by Messrs. E. Brainerd and Henry M. Seely, which disposes of the typical Calciferous, recorded as existing near Chazy village by Emmons and others, as not belonging to that formation. The authors of that paper have tried to make of it a new great division, regarded as the lower part of the Chazy, which they call "Group A of the Chazy Limestone." By that suppression of the true Calciferous at Chazy village and township we have there, according to the authors, a gap in the stratigraphy which they explain by a fault, or an instance of non-deposition,—they are not sure which—due to elevation of the sea bed in that region when what they call the Calciferous deposits were taking place. As the same strata of the Chazy village continue without interruption as far as lake St. Louis on the St. Lawrence river, and farther west, the typical Calciferous of New York and Canada is suppressed without any visible fault, or without any visible break. Then comes the problem how to account for placing between, what Messrs. Brainerd and Seely call the "Group A of the Chazy rocks" and the Potsdam sandstone, their new Calciferous formation or Phillipsburgh group, of a thickness of 1,800 feet, according to their calculation. They say they have found in Beckmantown, eight miles south of Chazy, their Calciferous, 300 or 400 feet only in thickness—not 1,800 feet—and they take a special care to omit to give either a section or description with fossil list.

The views of Messrs. Brainerd and Seely have been accepted and used lately in "Preliminary Report on the geology of Clinton County, New York," by Mr. H. P. Cushing (*New York State Museum, Report 47*, pp. 669-683, Albany, 1894); but without any proofs, by well observed stratigraphy or palæontological researches; simply calling to the rescue the supposed existence of numerous invisible faults, "which are frequently difficult to locate from lack of outcrops in sufficient number" (*Loc. cit.*, p. 669). As "the results presented are therefore merely tentative," the two geological maps accompanying the report do not sustain the classification of strata, with 1,800 feet of Calciferous sandrock, containing a fauna of more than one hundred species, placed between the Potsdam and the Chazy formation by Messrs. Brainerd and Seely.

GEOLOGY OF SHOREHAM (VERMONT).

During 1862 I visited, in company with my friend, the late John B. Perry, the village of Shoreham (Vermont) and found there a repetition of the same group of lenticular or islet masses of magnesian limestone, included in slates, as at Phillipsburgh, and also the same fauna with *Bathyrus*, *Maclurea*, *Lituites*, etc. Messrs. Brainerd and Seely have published in 1890 a geological map of East Shoreham, with two sections ("The Calciferous Formation in the Champlain Valley," in *Bulletin Amer. Museum Nat. Hist.*, vol. III, No. 1, pp. 1-23, New York), which fails to show the slates inclosing the magnesian limestone as lenticular or islet masses, and presents above the Phillipsburgh group (called by them Calciferous), in concordance of stratification, first the Chazy limestone, then the Trenton and above the Mica slates. Those three important groups of the Champlain system, so well developed at Chazy village and its environs, are here "rudimentary," according to those two authors, and no description, no list of fossils found in those three groups are given; so it is impossible to control in any way the determination of the age of those strata. As to the Potsdam sandstone at Shoreham, no fossils are given by the authors, and the stratigraphic position assigned to it below the Phillipsburgh group (Calciferous of Messrs. Brainerd and Seely) will require careful observations, as regards inclination of strata, dips, as well as fossils, if any can be found. As a conclusion, the classification of strata at Shoreham is made against all rules, and is simply an attempt by Messrs. Brainerd and Seely to suppress the Upper Taconic and refer it to the Champlain system.

[*To be continued.*]

THE RELATION OF THE STREAMS IN THE NEIGHBORHOOD OF PHILADELPHIA TO THE BRYN MAWR GRAVEL.

By F. BASCOM, Bryn Mawr, Penn.

In a paper upon "The Rocks near Philadelphia,"* which was published in the Proceedings of the Academy of Natural Sciences of Philadelphia, occurs the following statement:

"A remarkable feature of the part of Montgomery county and Chester county bordering on the Schuylkill is the direction taken by the streams. The general features are high hills extending in a northeast and southwest direction, with deep limestone valleys between, nearly at right angles to the general course of the Schuylkill.

"The streams, however, do not follow the valleys. The Wissahickon leaves the Montgomery county valley and flows eastwardly through a deep, narrow gorge, through very hard rocks, a distance of over five miles. The Valley creek flows down the Chester valley and then turns abruptly westwardly, and flows through the northwest boundary line. The Gulf creek flows down the valley two or three miles, then turns westwardly and flows through a deep and narrow gorge into another valley on the west, with banks rising abruptly two or three hundred feet."

These three streams, the Wissahickon, Valley creek and Gulf creek, whose peculiar courses are thus pointed out, are only the more marked illustrations of features which characterize all streams of the same class, flowing over the Piedmont plateau, in the neighborhood of Philadelphia.

The history of these streams will explain not only the directions pursued by them but also by the neighboring streams. Were it possible to read their story completely much light would be shed upon the still obscure post-Newark history of this portion of the Piedmont plateau.

While the following consideration of the stream history is manifestly incomplete, it still may suggest a possible criterion of the age of the superficial deposits of the plateau, which has not received much attention.

The present topography will be more readily understood if the discussion of the streams is preceeded by a brief resumé of the changes which produced the plain upon which they are at work. The pre-Newark history of the plateau must be read from the deposits and the larger rivers. It quite precedes the birth and growth of the present streams.

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*Rand, T. D., on The Rocks near Philadelphia. Proc. Academy of Natural Sciences of Philadelphia, May 29th, 1876, pp. 1-4.

Briefly, the deposits of that portion of the Piedmont plateau traversed by the streams in question (north and west of Philadelphia in Montgomery, Chester, Delaware, and Philadelphia counties) indicate that it must have passed through some such sequence of events as is outlined below: In later Algonkian and Lower Cambrian time it was a land surface. In Upper Cambrian time it was depressed and received a thin deposit of Cambrian and Ordovician sediments.

Early in the Ordovician period it was elevated, forming part of a lofty mountain range, which furnished continuous supply of material during all remaining Palæozoic time to the western sea. Then followed, upon the western portion, at least, of what was now a peneplain, the Newark depression and later elevation, reversing the direction of the rivers. Subsequent to this elevation occurred extended erosion, when the region was again reduced nearly to base-level. Thus, at the dawn of the Cretaceous, the Piedmont plateau was a plain slightly inclined seaward. From this point the story has been carried forward to mid-Cretaceous time by McGee.* Following upon the baseleveling mentioned above occurred, at the opening of Cretaceous time, the submergence which initiated the Potomac deposition. This deposit was at first a gravel, later with decreased declivity of the land the materials became finer. About the middle of Potomac time, there was, Mr. McGee thinks, in this region a temporary emergence of the land followed by submergence, when the upper member of the Potomac formation was deposited.

Since the deposition of these clays and gravels and other possible members of the Cretaceous series the plateau has perhaps been permanently above water.

What McGee has called the upper member of the Potomac formation is represented near Philadelphia by the plastic clays, which have been referred by the Second Geological Survey of Pennsylvania to the Wealden.† Some of the best exposures of this clay are found northeast of Conshohocken in the neighborhood of Harmanville (two miles from the Schuylkill on the county line road). At Keys' clay pits and at Pott's marble quarry, at an elevation of one hundred and eighty feet, these mottled clays are well seen. At the former locality the clays have a thickness of fifty-five feet. The succession of colors is yellow, red, white, blue (lignitic), yellow and mottled, red. The clays are overlaid by gravel varying from zero to eighteen feet in thickness and at a depth of fifty-five feet gravel again appears. At Keys' clay pits there is a steep dip to the south. About thirty feet below the surface in the lignitic clay were found fragments of wood.

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*McGee, W J: Three Formations of the Middle Atlantic Slope; Amer. Jour. Sci., volume xxv, 1888, pp. 142, 143.

†Report X. Hand Atlas of Pennsylvania. J. P. Lesley, 1885, pl. 46.

These are undoubtedly the "mottled clays" which Ward has recently referred to the Rappahannock series or "Basal Potomac."

Disassociated from and also in association with these clays is a gravel formation which has been known as the "Bryn Mawr gravel." This gravel is found in isolated patches at elevations of from three hundred and twenty-five (Media) to four hundred and fifty feet (one-third mile northwest of Gradyville) and is also (in the writer's opinion) the gravel which *overlies* the mottled clays. It also occurs in Delaware, where it covers the summits of some of the higher hills. (It has been observed by the writer one and one-half miles northwest of Wilmington, Delaware, at the crossing of the Lancaster turnpike by the Wilmington and Northern railroad.) The presence of an ironstone conglomerate serves as a ready means of recognition of the gravel. This conglomerate is made up of rounded waterworn pebbles of pellucid quartz, of milky white quartz, of quartz stained with the red oxide of iron and of friable quartzite, both white and amethystine, imbedded in a tough sandy and ferruginous matrix.

There are also present fragments of kaolinized feldspar and of what appears to be a siliceous limestone, from which the lime carbonate has been removed by solution. This detrital material ranges in size from a fine sand to pebbles which may be nearly six inches in diameter. (Pebbles of this size have been found by the writer in a conglomerate one-quarter mile west of Grassland, Delaware county.) The pebbles of the gravel are identical with those of the ironstone conglomerate and like them are associated with sand. A section shows coarse gravel, grading below into sand and fine pebbles, which in turn passes into a reddish clayey layer. The middle layer contains the conglomerate. So far as is known to the writer the gravel is further characterized by the absence of fossiliferous pebbles, of fragments of the Newark shale, of gneiss or garnetiferous mica-schist, or of any disintegrated igneous material. This gives it a lithological character, as well as a topography, distinct from the Jamesburg or Pensauken of New Jersey.

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*Ward, Lester F. The Potomac Formation. Fifteenth Annual Report U. S. Geol. Survey, pp. 324-336.

This gravel has been referred to the Tertiary (Upper Miocene) by the Second Geological Survey of Pennsylvania* and by Carvill Lewis† on the basis of lithological correlation with New Jersey gravels. On this basis it has also been referred to the Columbia,‡ with the Jamesburg of New Jersey. McGee claims that the gravel as examined by him, in exposures unfortunately of a more or less evanescent character, shows all the characteristics of the Potomac and is undoubtedly identical with exposures north and east of Conshohocken of a gravel *underlying* plastic clays, hence he makes it the "lower member" of the Potomac.§

The fact that the Bryn Mawr gravel is elsewhere found at so much higher altitudes than the clay, the presence of the ironstone conglomerate in the gravel overlying the clays at Pott's quarry and other localities, the general lithological similarity of this gravel with the Bryn Mawr gravel, and the dissimilarity, though slight, of the underlying gravel, have led the writer to reverse McGee's conclusion as to position. If the Bryn Mawr gravel is a member of the Rappahannock series, it must be an upper member of that series.

The Bryn Mawr gravel has thus been referred to Mesozoic, to Tertiary and to Quaternary time. Topographical and lithological dissimilarity with the Quaternary gravels of New

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*Second Geol. Survey Penn., Report C, 1885, pp. 10-13.

†Proc. Acad. Nat. Sci. Phila., 1880, pp. 269, 272, 488. Jour. Franklin Institute, volume 85, 1883, p. 373. Proc. Acad. Nat. Sci. Phila., 1884, p. 240.

‡Seventh Annual Report, U. S. Geol. Survey, p. 610.

§Amer. Jour. Sci., vol. xxxv, p. 130.

Jersey would seem to exclude it from that period. Will the evidence of stream erosion concur in that exclusion?

The plastic clays and the Bryn Mawr gravel rest alike upon contorted and eroded pre-Cambrian crystallines and upon upturned strata of Cambrian, Ordovician and Newark age. They rest upon the baseleveled plain of marked heterogeneity. Since this plain was baseleveled these two formations covered it to a depth varying from one hundred to two hundred and fifty or more feet.

With this past history thus briefly outlined, the present topography of the region can be readily comprehended.

The ancient Cretaceous baseleveled plain now stands at a fairly uniform hight of from four hundred to four hundred and fifty feet. This plain is trenched by valleys which have been excavated since the last elevation and since the deposition of Potomac clay and Bryn Mawr gravel.

The streams are far from reaching old age. Their head waters are still cutting back and contesting the watershed with streams farther west. The present discussion is concerned only with the *streams* and does not include the Schuylkill river, which is a compound and complex decendant of an original Permian river.

The Wissahickon, with its headwaters at a hight of four hundred and forty feet above sea-level, near Montgomeryville in Montgomery county, flows southwest and southeast across the Newark formation, then it turns and flows almost straight south, cutting across Cambrian sandstone and a belt of Ordovician limestone two miles wide. It leaves this non-resistant belt to erode a gorge in hard gneisses and quartziferous mica schists.

At Chelten avenue, Germantown, it receives a tributary and, turning abruptly, flows one and three-eighths miles southwest into the Schuylkill. Its course covers somewhat over twenty miles with a fall of four hundred and twenty feet.

The gorge of the Wissahickon in the crystalline schists is from one hundred and eighty to three hundred and fifty feet deep, and the stream is still carving with youthful vigor an ancient surface which bears the scars of other and far older agents of erosion.

The course of this youthful stream is directly transverse to the geological structure of the plateau and is entirely independent of the lithological character of the rocks over which it flows. This course admits of but one explanation, namely, that the Wissahickon is a superimposed stream, superimposed upon the Potomac clays and Bryn Mawr gravel through which it has cut its way. The gentle slope seaward of the plateau after the Cretaceous elevation determined the direction of the stream: Having trenched the clays and gravels, it found the hard crystallines beneath, but its course was too well established to be turned aside by the herterogeneous character of its newly discovered bed.

The abrupt turn at Chelten avenue and the subsequent course of the stream is evidently controlled by the tributary of which the Wissahickon becomes a part.

Valley creek is a stream some ten miles long which heads in the quartzite ridge forming the western boundary of Chester valley. It flows northeast over the limestone of Chester valley for some seven miles before it turns to the north at an angle of one hundred and thirty degrees to flow through a gorge cut in Cambrian quartzite rising three hundred and twenty and five hundred and ninety feet above the bed of the stream. At Valley Forge it empties into the Schuylkill. (See plate II.) For the last half mile its bed lies on the Newark formation. Like the Wissahickon, Valley creek is a superimposed stream. The cover of the Palæozoic sediments was undoubtedly in part the Newark formation as well as the Potomac gravels.

The way in which Valley creek, after following the strike of the limestone for some seven miles, leaves that easily eroded rock to traverse the hard strata, almost at right angles to its former course, would be remarkable under any other explanation than that of a superimposed course.

With the location of its bed due to the original slope of the land and fixed by superimposition, the subsequent erosion of a gorge through the quartzite, with the dip, becomes the most natural procedure.

The tendency of obliquely transverse streams, on upturned strata of different degrees of hardness, to gradually shift their courses until they become rectangular ones, along the strike of the soft bed and across the strike of the hard bed, cannot be ascribed to Valley creek as explained by Gilbert.*

Gulf creek rises in a ridge of mica-schist one-half mile north of Strafford station at an altitude of four hundred and eighty feet. It flows ten degrees north of east along the base of this ridge for about four miles when it turns at an angle of ninety degrees, cutting across the ridge, which, at this point, now stands at a hight of from four hundred to four hundred and eighty feet. After crossing this ridge the creek turns again at right angles and, flowing parallel to its original course, it empties into the Schuylkill at a level of fifty feet. (See plate II.) Gulf creek illustrates readjustment as well as superimposition. The adjustment occurred after the stream had cut through the Potomac cover and discovered the underlying crystallines of unequal hardness.

The early stream heading at *D* with two tributaries, *A* and *C*, soon cut a deeper channel in the limestone which formed its bed than its neighbor, *M*, on the other side of the mica-schist divide, was able to do in the gneiss in which its bed must be eroded.

The tributary *A*, by reason of the grade given it by the deepening channel of the main stream, was able to cut back through the mica-schist, with the dip, and eventually to rob *M* of its headwaters.

Since the capture of the headwaters of *M*, the channel of the diverted stream has rapidly deepened with the increased declivity and is now separated from the beheaded *M* by a low watershed, while *M* flows through a valley larger than its present volume warrants. A natural ponding on Gulf creek resulting from the sudden accession of detrital material brought by the tributary, has been utilized for artificial dams.

Similar transverse courses are pursued by Brandywine, Naaman, Chester, Ridley, Crum, Darby, Tacony, and Pennypack creeks which drain large areas of the plateau and empty into the Delaware between Wilmington, Delaware, and Holmesburg, Pennsylvania. If these streams were superimposed upon a cover of Bryn Mawr gravel they have accomplished all their work of erosion since the elevation of land which followed the deposit of that gravel.

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*Gilbert, G. K. Geology of the Henry Mountain. Geog. and Geol. Survey of the Rocky Mountain Region, p. 130.

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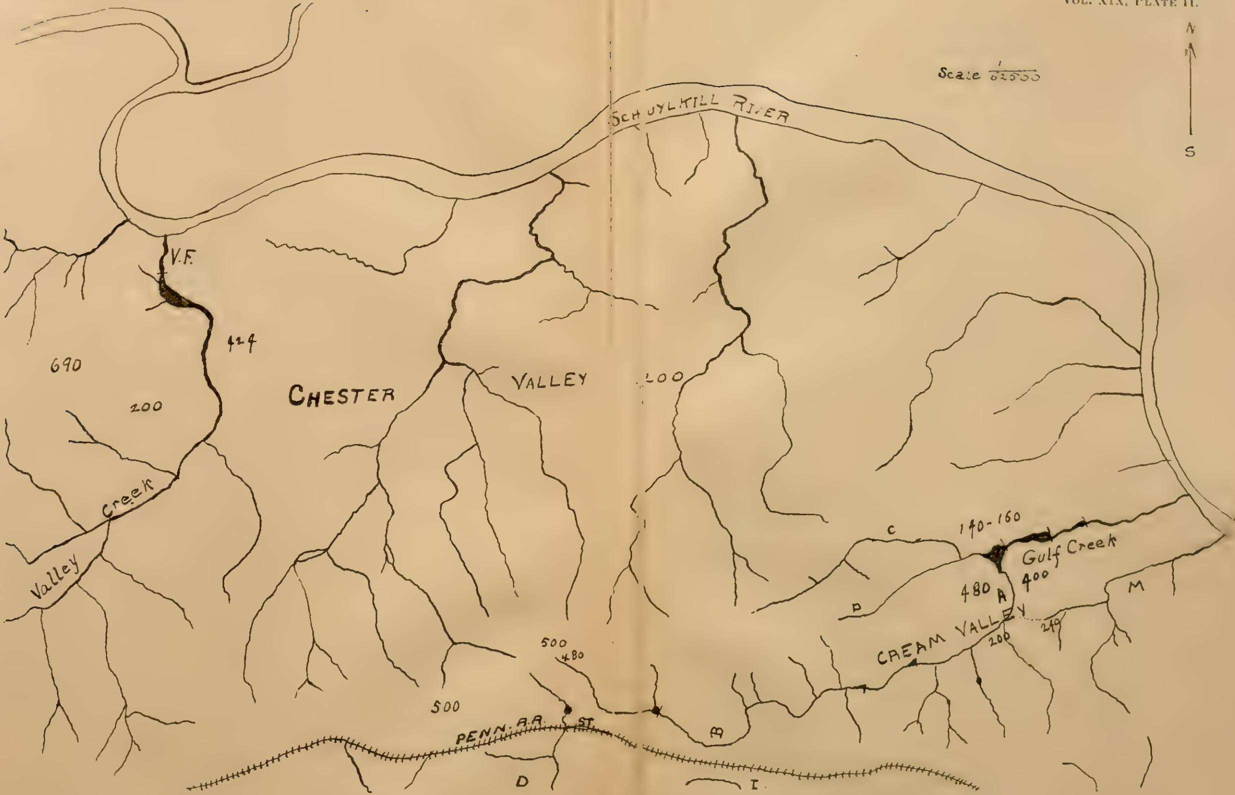

STREAMS OF THE PIEDMONT PLATEAU, NEAR PHILADELPHIA.

Their age is approximately the age of the gravel. They cannot be older, they may be younger. If the gravel is Columbia in age then the streams date from the close of that period or later. The question arises, could the streams have trenched such deep valleys and so extendedly contested the divide since Columbia time? We find the erosion in southeastern New Jersey of a less mature character. We find the Pensauken and Jamesburg gravels made up of material which must have been furnished them by streams draining this plateau.

The red shale of the Newark, disintegrated gneiss, granite, trap, garnetiferous crystalline schists and gabbro (the Brandywine, Naaman, and Crum creeks flow across gabbro areas) and rounded fragments of ironstone would be furnished abundantly by just such streams as the creeks described above, eroding first the Bryn Mawr gravel, then the crystalline schists and igneous rocks of the plateau.

These facts seem to concur in precluding the Quaternary age of the gravel.

It is perhaps not possible to determine the age of a drainage system with a degree of accuracy sufficient to distinguish between a late Mesozoic or an early Tertiary origin. On the other hand, the stream history furnishes no evidence against the Potomac (Mesozoic) age of the gravels.

The other members of the Potomac series were in all probability present in Pennsylvania and have either been completely removed by an erosion, dating back to the dawn of the Tertiary, or will yet be discovered in small areas.

That evidence of still more recent superficial deposits will be found seems highly improbable, hence the hypothesis has been stated that not very long after the deposit of the Bryn Mawr gravel the Pennsylvanian plateau was permanently elevated and the present streams began their work of erosion.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Underground Water of the Arkansas Valley in Eastern Colorado. By G. K. Gilbert. (Extract from 17th Annual Report of the U. S. Geol. Survey, Part II.) This paper, which illustrates well the various excellencies which we have learned to expect from Mr. Gilbert, is clear, concise, and complete. Its aim is to place in possession of the citizens of the region such knowledge of the geological formations and their relations to certain economic interests as will enable them to make them most available.

The region is the larger portion of the twelve or thirteen southeastern counties of the state of Colorado. It briefly describes the various geological formations giving the physical appearances and characteristic fossils of each. The latter are illustrated so that well diggers and others may make use of them in identifying the strata which they find. A synopsis of the formations is given in the following table:

Rock Strata of Southeastern Colorado.

CRETACEOUS	Fox Hills, sandstone and sandy shale		450 feet.
	PIERRE	Upper barren zone, shales	250–300 “
		Teepee zone, shales *Lucina occidentalis, Scaphites nodosus, Baculites, Heteroceras, etc.*	1,000 “
		Belemite zone, shales *Belemnites, Baculites, etc.*	100–150 “
		Rusty zone, shales Iron concretions.	600 “
		Lower barren zone, shales Much selenite.	450–500 “
	NIOBRARA	Apishapa shales Fish scales and bones.	500 “
		Timpas, limestone *Inoceramus deformis, Ostrea congesta.*	175 “
	BENTON	Carlile shales *Prionocyclus wyomingensis.*	175–200 “
		Greenhorn limestone *Inoceramus labiatus.*	25–40 “
		Graneros shales	200–210 “
	Dakota sandstones and shales		200–500 “
Jura-Trias, sandstones and shales of red color			2,000 “

The dip of these formations, especially of the older, is to the north-northeast from the foot of the mountains.

Besides these older formations of the Cretaceous there are recognized the Upland Sands and Gravels, which the author ascribes to the action of streams, lakes and winds, at a time when the drainage of the region was much more sluggish than at present; the Terrace Sands and Gravels, which cap the higher terraces along the main streams, and the Dune Sands, which had accumulated at various epochs.

Perhaps the most important economic feature of the paper is that treating of artesian wells. Water is a desideratum in that region and is obtained from two general sources: one, the deeper or artesian supply, the other, the waters permeating the loose deposits near the surface. The artesian supply is here, as further north, mainly from the Dakota formation, which is described as being made up of different layers of a yellow or brown sand more or less separated by impervious layers of shale. The Jura-Trias is considered to be quite impervious to water. No successful wells have been obtained from it. Above the Dakota sandstone the remaining members of the Cretaceous are almost entirely impervious shales. A map is given of an elongated region corresponding in a general way to the Arkansas valley in which flowing wells may be obtained. Along the south and west sides of this area wells may be obtained at a depth less than a thousand feet, but along the northern side throughout a narrower strip they cannot be obtained without going to a greater depth. The former area is estimated to be about 4,000 square miles, and the latter 1,500. Some valuable statements are given concerning the areas in which the water is collected. The average width of the exposure of the Dakota formation along the foot hills is estimated to be not more than one mile. "Where it is narrow the slopes are so steep that a large share of the storm water runs off and the sand can imbibe but little. But the broader parts of the belt have gentle slopes more or less covered by a blanket of sand, in which the rain water is stored for a time and from which it may be slowly absorbed by the sandstone."

He outlines several areas of this sort, one having an area of fifty or sixty square miles, another of five hundred, and a third of not less than a thousand. The author remarks, "It is impossible to say what share of these areas contributes water to the sandstone. In part they are occupied by the upper layers of sandstone, which are of so fine texture as to receive little water. The irregularity of the sandstone beds is so great as to raise the question whether all the porous beds exposed to the rain are of such horizontal extent as to carry water to the deeply buried portions of the formation. Such considerations make it impossible to estimate the amount of water which may annually be imbibed, and for the present at least it is useless to discuss the annual rainfall with reference to the extent of the gathering grounds."

The artesian waters are found to vary much according to locality. In general they are rich in chlorides, sulphates, carbonates of sodium, calcium, magnesium, with frequent occurrence of silica and lithia, in proportions varying from .0008-.0036.

The ground water of the region is derived mainly from the Upland Sand and Gravel. Considerable attention was given to circulation of water in the sand occupying the stream beds, as well as those of the terraces and upland. In the Arkansas river, as in most rivers of the plains, a large portion of the water is flowing beneath the surface of a vast amount of sand filling its channel. Upon the upland the water contributed by rainfall is found here, as in other regions, to have a very irregular surface, corresponding sometimes to the surface of the underlying rock, sometimes to the surface of the soil and at other times apparently without relation to either.

Some interesting experiments were made to determine the absorptive power of sands. The experiments were performed by filling a vessel with sand thoroughly dried, then pouring into it water until it was saturated, then by puncturing the bottom of the vessel so as to permit the water to drain away, and after a lapse of several days determining the amount of water lost. The amounts in each case were determined by weighing. It was found that the sand in one case had received 29 per cent. of its volume of water, but afterwards parted with only one-third. In one case the sand taken from an ancient deposit on the face of "The Mesa" near Santa Fe avenue, in Pueblo, absorbed 29 per cent. of its volume of water and delivered only 3 per cent. This illustrates forcibly the adhesion of the water to the sand, which forms an important factor in estimating its friction and the rate at which the water may percolate through sands either near the surface or in an artesian stratum.

The paper may be heartily commended as a model of careful, scientific investigation and a popular presentation of economic results, such as should often be the aim of the governmental expenditure of public funds. J. E. T.

On the Apical End of Endoceras. By GERHARD HOLM. (Om apikaländan hos Endoceras; Geol. Fören. i Stockholm Förhandl. vol. 18, pt. 5, p. 394-426; 1896.) Herein Holm has summarized all that is now known of the very rare fossil apical ends of *Endoceras* shells. The excerpt at hand is in Swedish, and is accompanied by six excellent octavo plates, besides three figures in the text.

In review, from the literature on the subject, Holm begins with the observations by Barrande[*] (1870), who described and figured a specimen of *Orthoceras marcoui* Barr., and who considered the same as still possessing the apical end of the shell. Holm himself in 1885[†] described and figured the structure of the apical portion of the shell as well as the development of it in *Endoceras belemnitiforme* Holm, and pointed out the difference between this one and the much smaller septate apex of *E. bouchardi* Dew. Remelé (1885)[‡] mentioned two *Orthoceras* shells with bent initial part. Foord[§] in 1888 showed that the *Orthoceras marcoui* described by Barrande consists only of the apical portion of the siphon itself. In 1889 Rudinger[||] mentioned a specimen of *Endoceras* which has the apical end bent towards the siphonal side. Hyatt[¶] (1889), after citing Holm's description of *E. belemnitiforme*, pointed out further the relation of the diminution in size of the siphon to the septa. Again in 1892 Holm[**] presented his observations on three species of *Endoceras* with preserved apical portion, one of which is like *E. belemnitiforme* Holm, except that the initial portion or apical cone of the siphon attained less size. The other two have the apex of the shell septate, but the siphon is swelled and later constricted before assuming its normal size. Both of the same are characterized by the curving of the apical end *Cyrtoceras*-like, toward the siphonal side.

Clarke[††] (1894), without knowing of Holm's description of *Endoceras belemnitiforme*, described the apical end of a very nearly related new

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[*] Syst. Sil., Cephalop., pl. 431, fig. 11-13; text part 3, p. 748.

[†] Palæont. Abhandl. vol. 3, pt. 1, p. 4, pl. 1, fig. 1-5.

[‡] No. 113 in "Katalog der von Prof. Dr. Ad. Remelé beim international Geologen-Congress zu Berlin im 1885 ausgestellten Geschiebesammlung."

[§] Cat. Foss. Cephal., part I, p. 132.

Arch. Ver. Freund. Nat. Mecklemb., Jahr, 1891.

[¶] Genesis of the Arietidæ, p. 13.

[**] Geol. Fören. Förh., vol. 14, p. 71-72.

[††] AMER. GEOL., vol. 14, Oct., 1894, p. 205, pl. 6.

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species from North America, which he calls a new cephalopod type because of the structure of the apical end, and he called the same by a new name, *Nanno aulema* Clarke. Sardeson* (1894) and Bather† (1894) both pointed out that *Nanno* is far from a new cephalopod type. Hyatt‡ (1895) confirmed in main Clarke's description of the apical end of *Nanno aulema*. Holm here quotes in a foot-note Hyatt's introductory words, viz., "The discovery and description of this genus by Prof. J. M. Clarke has materially added to our knowledge of the structure and development of the siphon in the *Endoceratidæ* and thrown a new light upon the affinities of the forms of this group," and comments upon them as inexplicable, inasmuch as Sardeson and Bather had pointed out that Holm had in 1886, or nine years earlier, more thoroughly and extensively described the cephalopod type in question.

Further Hyatt considered *Nanno aulema*, because of the structure of the siphonal tubes, as generically distinct from *Endoceras belemnitiforme* Holm, but he seems, says Holm, not to have had sufficient materials. He is quoted much in full because his observations are so indefinite.

Holm§ (1895) described and figured the endosiphonal structure of *Endoceras (Nanno) belemnitiforme* and shows the same to be like that of *E. wahlingbergi* Foord, with a cicatrix opening in the same manner as in Piloceras, from which it was concluded,—Bather's views notwithstanding,—that *E. belemnitiforme* and related forms, similar to other *Nautiloidea*, have a fragile, easily destructible protoconch. The near relationship between *Nanno aulema* Clarke and *Endoceras belemnitiforme* Holm was determined and *Nanno* adopted as a subgenus of *Endoceras*.

After reviewing the literature Holm presents further observations upon the apical structures of *Endoceras*. He recognizes two types of these structures in *Endoceras*, but considers the division of the genus as impracticable, since the apical cones of very few species of this large group are known, and among the few is not found the type species itself of *Endoceras*. He therefore recognizes two subgenera, *Nanno*, type *E. aulema* (Clarke) and *Suecoceras*, type *E. barrandei* Dew., the former of which he considers as the more primitive form. He defines them as follows:

SUBGEN. 1. NANNO (Clarke). Siphon with the apical end strongly swelled so that back of the first loculus there is formed an apical cone of the shell, which is entirely filled by the siphonal apical cone, the latter equalling in length, in all known cases, the combined width of at least three of the first chambers. Thereafter the siphon tapers forwards so rapidly that the same attains its normal dimension within the third septal chamber.

SUBGEN. 2. SUECOCERAS Holm. Siphon completely filling the shell's apical end, with narrow apex, and on the siphonal side in contact with the outer shell of the conch, forming within a series of the first loculi a quickly expanding initial cone, likewise again decreasing in size to its normal dimension. The first loculus therefore includes the apex itself.

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*AMER. GEOL., vol. 14, Dec., 1894, p. 402.

†Natural Science, vol. 5, No. 34, Dec., '94, p. 431.

‡AMER. GEOL., vol. 16, July, 1895, p. 1, pl. 1.

§Geol. Fören. Förh., vol. 17, p. 616, pl. 22, fig. 9-13.

In some forms of *Suecoceras* the apical cone is a little curved, *Cyrtoceras*-like, towards the siphonal side, the point of greatest curve coinciding with, or a little forward of, the siphon's point of greatest diameter.

The following species are described: *Endoceras* (*Nanno*) *aulema* (Clarke), *E.* (*Nanno*) *belemnitiforme* Holm, *E.* (*Nanno*) *fistula* Holm, n. sp., *E.* (*Nanno*) *pygmæum* Holm, n. sp., *E.* (*Suecoceras*) *barrandei* Dew., *E.* (*Suecoceras*) *gibbum* Holm, n. sp., *E.* (*Suecoceras*) *recurvum* Holm, n. sp., *E.* (*Suecoceras*) *dux* Holm, n. sp., *E.* (*Suecoceras*) sp., *E.* (*Suecoceras*) *papilla* Holm, n. sp., *E.* (*Suecoceras*) *marcoui* Barr.

F. W. S.

Faunas of the Paradoxides Beds in Eastern North America—No. 1. By G. F. Matthew. (Trans. N. Y. Acad. Sci., vol. xv, Aug. 3, 1896, pp. 192-247.) In his introduction to the paper on the Protolenus Fauna* the above author outlined the subfaunas into which the American Paradoxides fauna may be divided. More definiteness is given this view of the life of the middle Cambrian by showing the species which are peculiar to each subfauna, so far as they are described in this article.

Only the smaller crustaceans are dealt with in this paper, which is valuable especially as giving a full account of the species of Agnostus and Microdiscus as they appear in the Paradoxides beds of America.

A good many European species of Agnostus are recognized as occurring in these beds, either in their European form or as varieties, showing the close relation that existed during Middle Cambrian time, between the faunas on the two sides of the Atlantic. Some points interesting to the biologist are made out by a study of the development of the larva in Agnostus. The earlier moults show a near resemblance to other trilobites of the Paradoxides beds. This resemblance is apparent in the form and details, both of the headshield and pygidium. As regards the latter it is said to show three stages of development during growth. 1st, The early larval stage—nonagnostiform—when it possessed 1-3 somites; 2d, the later larval stage—agnostiform—when it had about 4-5 somites; 3d, the adult condition when it had about 6-7 somites and the three main lobes of the rachis were developed. Of these somites, 4-5 were in the posterior lobe of the rachis of the pygidium. The special features of the sections of Agnostus designated *Parvifrontes* and *Lævigati* by Tullburg resulted from the progressive effacement of those of the earlier types, presumably impressed in early larval stages.

The species of Agnostus recognized as occurring in the middle Cambrian of eastern North America are the following:

Regii, *A. regulus* Matt.; *A. rex* Barr., var. *transectus*, n. var.; Fallaces, *A. fallax* Linrs., var. *vir* Matt., var. *concinnus* Matt., var. *trilo-*

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*Trans. N. Y. Acad. Sci., vol. xiv. Mar. 17, 1895.

batus, n. var.; *A. acadicus* Hartt., var. *declivis* Matt.; Parvifrontes, *A. parvifrons* Linrs., var. *tessella* Matt., var. *truncatus*, n. var.?; *A. umbo* Matt.; Longifrontes, *A. obtusilobus* Matt.: *A. davidis* Hicks, *A. gibbus* Linrs., var. *partitus* Matt., var. *acutilobus* Matt.: *A. nathorsti* Brögg., var. *confluens*, n. var., *A. fissus* Lundg., var. *trifissus*, n. var.; *A. punctuosus* Ang. Lævigati, *A. lævigatus Dalm.*, var. *terranovicus*, n. var., var. *ciceroides*, n. var., var. *mamilla*, n. var.: *A. nudus* Beyr.?

Figures of these Agnosti appear on three plates of the memoir.

The Disseminated Lead Ores of Southeastern Missouri. By Arthur Winslow. Bulletin 132, U. S. Geological Survey; 31 pages, with six plates (maps and cross-sections), and three figures in the text; 1896. The structure and areal geology of this district are described and mapped, with notes of recent progress in mining and the general distribution of the ore as revealed by drilling. The ore-bearing formation is the St. Joseph limestone, in which galena is desseminated through beds varying within short distances from one or two feet up to ten or twenty feet in thickness. Mining on a large scale began soon after the close of the civil war, and several new mines have been opened during the last five years. W. U.

Contributions to the Cretaceous Paleontology of the Pacific Coast: The Fauna of the Knoxville Beds. By Timothy W. Stanton. Bulletin 133, U. S. Geol. Survey; 132 pages, with 20 plates; 1895. Structurally and faunally, these Aucella-bearing beds, occurring in the Coast ranges of California, Oregon, and Washington, seem to constitute a single and well defined geological formation. The fauna, however, shows a gradual change from the lower to the upper beds, while yet having no distinct break which would justify referring one portion to the Jurassic and another to the Cretaceous. The author regards the whole formation as of Neocomian age. It has 77 species and varieties of invertebrates, as here described, of which 50 are new, 12 have been previously described, and the remaining 15, on account of insufficient material, can be only generically determined. W. U.

Bibliography of Missouri Geology. By C. R. Keyes. (Mo. Geol. Surv., vol. 10, pp. 219-523, 1896.) This article is the last in the tenth volume of the present Missouri Survey, which volume will soon be distributed. The bibliography includes (1) an authors' index, containing the full title, pages, etc., and a very brief synopsis of each article; (2) a title index; and (3) subject entries and cross references. In this manner each article is entered at least three times and many appear more than three times. Moreover, whenever an article is entered it appears with its full title, author and place of publication. This of course much increases the bulk of the bibliography, but at the same time it makes it more serviceable in doing away with the necessity of turning from one title to another to find a complete reference. The present work differs considerably in plan and scope from the earlier bibliography of Missouri geology by F. A. Sampson (Mo. Geol. Surv., Bull. 2, 1890). U. S. G.

The Eocene Deposits of the Middle Atlantic Slope in Delaware, Maryland and Virginia. By WILLIAM BULLOCK CLARK. (U. S. Geol. Survey, Bull. 141, 167 pp., 40 pls., 1896.) The Eocene strata (Pamunkey formation of Darton) of the Middle Atlantic slope form a distinct unit, being separated from the Cretaceous below and from the Miocene above by erosion intervals. In lithologic character these deposits are essentially glauconitic, and they contain a considerable fauna, although the state of preservation of the fossils has heretofore caused a large number of the Eocene forms to be overlooked. The strata strike north and south, or northeast and southwest in the northern part of the area, and the dip is toward the east or southeast, averaging twelve and one-half feet per mile. The average thickness is about 200 feet, although in places the beds attain a thickness of 300 feet. From the Potomac River section, which is the best and most characteristic section exposed, the author has been able to establish two clearly defined paleontologic stages,—a lower or Aquia Creek stage, and an upper or Woodstock stage,—but it is not possible to recognize over the whole area minute paleontologic or lithologic divisions.

In discussing the correlation of the Middle Atlantic Slope Eocene with the Gulf Eocene Prof. Clark calls attention to the diverse views on this subject and also to the different conditions under which the deposits were laid down. In the former region the strata were accumulated slowly at some distance from the shore and along a coast which received no large rivers, while in the latter region the accumulation was rapid and more extensive and was largely influenced by the débris brought down by large rivers. The author concludes that the Middle Atlantic Slope Eocene is the equivalent in a broad way of most of the Gulf series, except that the upper part of this series is probably lacking in the region he is discussing. The Aquia Creek stage is broadly the equivalent of the Lignitic, and the Woodstock of the Claiborne.

The work contains a bibliography of the subject, a historical review of investigations, a brief outline of Coastal Plain history, a discussion of criteria of correlation, and descriptions of the fauna, which is illustrated by thirty-six plates. U. S. G.

The Cambrian Rocks of Pennsylvania. By CHARLES D. WALCOTT. Bulletin 134, U. S. Geol. Survey; 43 pages, with 15 plates; 1896. This paper gives the results of field work in 1892 and 1893. The discovery of the Olenellus or Lower Cambrian fauna in the Reading sandstone supplies the completing link in the correlation of the basal quartzites of the Cambrian series along their entire extent from Vermont to Tennessee. Much further work is needed for determination of the division between the Cambrian and Ordovician series in this region. Intraformational conglomerates, in thin bands, are described as observed in many localities. Their origin is ascribed to tidal action on gently sloping shores or on the flats of estuaries, hardened layers due to drying when exposed by the ebb of the tide having been broken up by the incoming tide.

W. U.

Annual Report of the Inspector of Mines of Kentucky for 1895. By C. J. Norwood, Chief Inspector and Curator of the Geological Department, and W. U. Grider, Assistant. Pp. vii, 326, Louisville, 1896.

This report is not, like so many which deal with mine inspection, simply a list of mines and of the accidents which have occurred in them during the year. Planned and prepared on a liberal scale, by a competent geologist, it contains the usual statistical data in considerable detail and then goes on to give an account of the various mines in one chapter of 70 pages, a paper on "Coal-dust as an Explosive Agent," pp. 171-191; one on "Coking and Coal-washing at Earlington," by J. B. Atkinson, pp. 191-207: a chapter on "Steam Tests of Kentucky Coal," pp. 208-243; a general article on "Kentucky Mineral Wealth," by C. J. Norwood, pp. 243-292, and chapters on petroleum and phosphates in Kentucky and the prevailing laws relating to mining.

From the statistical data we learn that there were 138 coal mines in operation in 1895. These produced 3,207,770 short tons of coal, worth 80.5 cents per ton at the mine. There were produced 25,450 tons of coke in 214 ovens.

The paper on the mineral wealth of the state is a valuable resume and contains references to the coal, iron ores, fluor spar, baryta, lead, asphaltum, clays, petroleum and building stones. H. V. W.

RECENT PUBLICATIONS.

IV. *Excerpts and Individual Publications.*

Manual of determinative mineralogy, with an introduction on blowpipe analysis, by G. J. Brush. Revised and enlarged by S. L. Penfield. 8vo, ix, 163, 63-108 pp.: New York, John Wiley and Sons, 1896.

L'extension du système taconique vers l'Ouest, N. H. Winchell. Compte-rendu du Cong. géol. intern., 6e Ses. (Zurich, 1894), pp. 272-308, 1896.

Faunas of the Paradoxides beds in eastern North America, No. 1, G. F. Matthew. Trans. N. Y. Acad. Sci., vol. 15, pp. 192-247, pls. 14-17, Aug. 3, 1896.

The Jura of Texas, Jules Marcou. Proc. Boston Soc. Nat. Hist., vol. 27, pp. 149-158, Oct., 1896.

On the fracture system of joints, with remarks on certain great fractures, J. B. Woodworth. Ibid., pp. 163-483, pls. 1-5, Nov., 1896.

A new occurrence of Carboniferous fossils in the Narragansett basin, M. L. Fuller. Ibid., pp. 195-199, 1896.

Bibliography of Missouri geology, C. R. Keyes. Mo. Geol. Survey, vol. 10, pp. 219-523, 1896.

Catalogue of the fossils of the Trenton and Cincinnati periods occurring in the vicinity of Cincinnati, O., G. W. Harper and R. S. Bassler. 34 pp.; Cincinnati, W. B. Carpenter Co., 1896.

A geological reconnaissance in northwestern Oregon, J. S. Diller. U. S. Geol. Survey, 17th Ann. Rept., pt. 1, pp. 1-80, pls. 4-16, 1896.

Traces of organic remains from the Huronian (?) series at Iron Mountain, Mich., W. S. Gresley. Trans. Amer. Inst. Mining Eng., Colorado meeting, Sept., 1896; 8 pp.

Faulting in glacial gravel, W. S. Gresley. Ibid., 2 pp.

The geology of the Sand hills of New Jersey, W. B. Clark and G. B. Shattuck. Johns Hopkins Univ. Circulars, vol. 16, 4 pp., 1897.

V. *Proceedings of Scientific Laboratories, etc.*

Bull. Mus. Comp. Zool., vol. 28, no. 2, (Geol. Ser. vol. 3), pp. 29-62, pls. 1-26, Oct., 1896. The elevated reef of Florida, Alexander Agassiz; with notes on the geology of southern Florida, L. S. Griswold.

Same, vol. 28. no. 3, (Geol. Ser. vol. 3), pp. 65-91, Dec., 1896. Notes on the artesian well sunk at Key West, Florida, in 1895, E. O. Hovey.

CORRESPONDENCE.

The age of the California Coast Ranges. Mr. Fairbanks having seen fit to offer, under the foregoing heading, certain friendly criticisms upon a recent paper by me, on the Great Valley of California, a few words in reply may not be amiss, as showing that the real difference between our views is not so wide as he seems to imagine.

To begin with, the criticism seems to have rather overlooked the fact that the main object of the paper discussed was a study of the theory of isostasy with special application to the Great Valley, and not an exhaustive discussion of the various oscillatory movements that may have affected that portion of the earth's crust now occupied by the Coast ranges. It was far from my intention to deny the fact of these oscillations, or the former existence of pre-Miocene land masses within this area. As a matter of fact, such older land areas are distinctly mentioned on page 424, and elsewhere within the paper. But to speak of these older land masses as "the Coast ranges," and to assume that they held substantially the same relations toward the interior valley and coast line that the mountain ranges of that name now do, or have done since the close of the Miocene, is a very different matter.

It may be true, as Mr. Fairbanks suggests, that the discussion of such oscillations as he refers to *might* materially strengthen the case against isostasy, but it is also conceivable that the discussion of such a broad principle may have its value largely increased by a decided tendency toward conservatism in the selection of the fundamental data from which the deductions are drawn. In the present state of our knowledge it does not appear possible to connect these movements with the morphogeny of the Great Valley in a sufficiently definite manner to add any value to the discussion in hand.

Mr. Fairbanks says that "the Miocene was terminated by one of the most marked changes of level recorded in the history of the region. This change was in the nature of a great uplift with the formation of several new ranges," and with this statement I am in substantial agreement. Our main difference is purely one of definition. He would include under the term "Coast Ranges" such land masses as may have existed on or near the line of the present mountains prior to that upheaval, while I am disposed to restrict the name (particularly in the present discussson) to the physiographic features initiated by so radical a transformation as then took place. We do not know how far or in what direction these older landmasses extended. The conditions, during the Miocene, which allowed the accumulation of the very extensive Miocene deposits which make up so large a portion of the Coast Ranges, were certainly very different from those which have obtained since the beginning of the Pliocene; and it does not appear that sufficient correspondence has been made out between the early Miocene distribution of land and sea, and that of the present day, to warrant us in speaking of these earlier landmasses as the "Coast Ranges." There is, in brief, nothing in the literature that will enable us to reconstruct a Miocene or pre-Miocene "Great Valley" which can be satisfactorily shown to have any direct genetic connection with the present Great Valley of California. The quotation from Diller which is advanced as indicating the existence of the Coast Ranges and interior valley in Cretaceous times, namely, "that during the Shasta-Chico period the Coast range existed, but did not furnish sufficient obstruction to keep the *open sea* out of the Sacramento Valley," contains within itself the suggestion of my objections to Mr. Fairbanks' terminology. Moreover, this statement refers only to the northern part of what we know as the Great Valley, and leaves room for the interpretation of a very different physiography from that which is known to date from the post-Miocene uplift and folding.

F. LESLIE RANSOME.

Harvard University, Dec. 9, 1896.

PERSONAL AND SCIENTIFIC NEWS.

THE MARYLAND GEOLOGICAL SURVEY has undertaken a magnetic survey of the state. This work is under the direction of Prof. L. A. Bauer. Already observations of the three magnetic elements have been made at about forty stations, averaging one station to every 250 square miles. The ultimate average will be one station to about 140 square miles. A report on this work is expected to be issued some time this winter.

WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS. At the late meeting of this Society geological papers were announced as follows:

The Berlin and Utley quartz porphyries and Waushara granite, *Samuel Weidman.*

The pre-Cambrian volcanic rocks of the Fox river valley, *Wm. H. Hobbs, C. K. Leith* and *W. W. Pretts.*

Glacial Phenomena of the Baraboo district, *R. D. Salisbury.*

Certain physical features of Wisconsin, *G. L. Collie.*

Relations of faults, complex fractures, fissility and cleavage to lengthening and shortening the crust of the earth, *C. R. Van Hise.*

The opening address was given by Prof. R. D. SALISBURY, with lantern projections, on "*Greenland*," and the retiring address of the president, Prof. C. R. Van Hise, was on "*Earth Movements*." The meeting was held at Milwaukee, Dec. 28-30.

MASTODON AMERICANUS. In the museum of Earlham college at Richmond, Ind., has recently been erected a fine skeleton of this extinct mammal, a photograph of which, sent to the GEOLOGIST by Prof. Jos. Moore, shows it is one of the best in the country. The following particulars are given by Mr. Moore:

This skeleton is built of the combined remnants of two mastodons; the one found near New Paris, Ohio, the other near Losantsville, Randolph county, Indiana. The two were so nearly on the same scale that the one served to piece out the other.

The cranium is the original head of the Randolph find. It was much broken in taking it out of the mud, but the large fragments were rearranged in natural order and the vacancies filled in with paper pulp by Ward & Co.

The lower jaw is bone throughout. All the grinders are natural teeth. The tusks are paper, but are exactly modelled after originals which belong to a very large skull found in Orange county, New York. One of the original tusks, the left, lies on the platform. It was too brittle and heavy to mount. Of the vertebræ, including those of the neck, body and tail, thirty-six are bone. Of the thirty-eight ribs all are bone but three. The sternum is bone. All parts of the fore legs are bone except the left humerus. The fore feet are almost entirely bone. The shoulder blades are bone throughout their length, but the borders are restored in plaster. The hind legs are all bone except the fibula of the left leg. The pelvis is a restoration from the massive fragments of the original.

From the pedestal to the top of the highest spine is eleven feet, less half an inch. From pedestal to top of head is eleven feet, two inches. From pedestal to summit of pelvis, nine feet. Horizontal width of pelvis, six ft., three inches. From forward curve of tusks to backward curve of tail is twenty feet, two inches. From sole of foot to top of scapula, nine feet, seven inches. The femur is 46½ inches long; tibia 28½ inches; humerus 39¼ inches; ulna 34 inches; scapula 38 inches. Estimated weight when alive, about ten tons. It ranks among the largest of known mastodons.

The skeleton was mounted in the summer of 1895 by Joseph Moore and Caswell Grave, and remounted by the same in the summer of 1896.

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Ch. Fred. Hartt

THE AMERICAN GEOLOGIST,
Vol. XIX, Plate III.

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THE
AMERICAN GEOLOGIST.

Vol. XIX. FEBRUARY, 1897. No. 2

PROFESSOR CH. FRED. HARTT. M. A.
A TRIBUTE.*

By Frederic W. Simonds, Austin, Texas.

[Portrait.]

I.

Nearly a quarter of a century has passed since, as a student of geology, I entered the laboratory of this gifted man. A teacher full of youthful enthusiasm, an original worker glowing with scientific zeal, a friend full of sympathy and love—this, my first impression, years have not dimmed. To study in his presence was indeed a pleasure, and, as the days and weeks sped by, my respect and admiration for him knew no bounds. To his students he was an ideal teacher whose word of commendation brought redoubled efforts to please.

Professor Hartt at this time, the autumn of 1872, filled the chair of Economic, General and Agricultural Geology in a new, but already famous institution—Cornell University. He was a member of the original faculty which assembled in Ithaca at the opening of the university in 1868, having resigned the chair of Natural History in Vassar College, after a brief period of service, for, as it doubtless appeared to him, a wider field of usefulness. I well remember my first visit to his laboratory, on the second floor of the south wing of the recently completed McGraw building. At a small table, in a large room, surrounded by boxes, barrels and trays, sat the indefatigable worker. The wealth of a recent Brazilian expedition demanded the attention of himself and his assistants. For special students there was, as yet, no place, not a chair nor a table. Furniture was, however, soon provided and in a few days work began in earnest.

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*The accompanying likeness represents professor Hartt as he is remembered by those who knew him in this country, especially his friends at Cornell University. In Brazil he became more robust and wore a full beard, which altered somewhat his appearance.

Hartt had been a student of the elder Agassiz at Cambridge and had made his first trip to Brazil with that great teacher; naturally, therefore, it must be expected that his methods would be influenced by his training. That they were, I have no doubt.

He subjected each student entering his laboratory to some preliminary test and in that way surrounded himself with the best material, for the less fortunate ones, if not told so directly, soon found that the work of a geological laboratory was not their forte and retired. He seemed to feel that a busy man of science could ill afford to waste his energies on material which, at the outset, promised to bear no fruit.

The instruction offered was individual, adapted largely to the taste or inclination of the student. Almost all the work was palæontological, consisting of the collection, identification, description and drawing of fossils. This form of instruction aroused in many of his students great interest and they soon became familiar with the Middle Devonian fauna of the lake region of central New York.

Different phases of work were developed on special occasions. For instance, among the then recent purchases of the university was a large collection of casts and models of celebrated fossils, some of which, it must be admitted, were not as accurate as they should have been. To a person of Hartt's artistic instinct the defects were glaring. It is not surprising, therefore, that, with the assistance of some of his students, he should have attempted to produce better and more accurate results. That his experiments were a great success is attested by the models of *Eurypterus remipes* and *Asaphus gigas* still to be seen at Cornell.

But the greatest source of our inspiration lay in the fact that our teacher carried on his private work in our presence.

His industry, patience and devotion served us as an example; his enthusiasm aroused us—we seemed to share with him his labor. Research, investigation, they had for us a different meaning now—had we not seen the truth-seeker as he unraveled nature's secrets? Manuscripts, drawings, publications, conversations in the brief intervals of rest,—all kept the youthful mind in a glow of healthful excitement. And soon, under his fostering care, some of the advanced and special students began the preparation of original papers.

A glimpse of his inner life may be had from this bit of conversation held, in my presence, with a lady visitor. After explaining that he rarely made formal calls, he glanced kindly towards a group of his students, saying, "These are my associates—my friends." This was characteristic of professor Hartt. He was affectionately bound to those with whom he worked,—they constituted the little world of his daily existence. And the feelings of confidence and esteem so manifest to them were reciprocated by that youthful band, who, inspired by the work and words of their beloved professor have since carried on geological teaching and investigation.*

Hartt recognized fully the importance of field work as a part of geological training. The glens and gorges about Ithaca afforded ample collecting grounds, not to mention the opportunities offered for more extended exploration by the formations exposed along the shore of Cayuga lake. Annual excursions to interesting localities were also planned for members of the classes in the elementary courses and such others as wished to join them. In the latter part of May, 1873, over 80 students under his guidance visited the coal mines and kindred interests at Scranton, Pa., and the following year a large party visited the gorge and falls at Niagara.

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*Of his former students now actively engaged in scientific pursuits, mention may be made of Dr. J. C. Branner, of Stanford University, California; Dr. Theo. B. Comstock, lately president of the University of Arizona; Dr. O. A. Derby, of Sao Paulo, Brazil; professor H. L. Fairchild, of the University of Rochester, New York; Hon. W. F. E. Gurley, State Geologist of Illinois; Mr. Richard Rathbun, of the U. S. Fish Commission, Washington, D. C.; Mr. H. H. Smith, of Brooklyn, New York; and Dr. F. W. Simonds, of the University of Texas. Further, his influence over the large classes which always thronged his lecture room was great, and to-day, widely scattered over our country, may be found men, in educational and other fields of usefulness, who owe much to the inspiring personality of their teacher.

As a lecturer, professor Hartt was clear, concise and magnetic. He was, moreover, an artist and his ideas were frequently reinforced by the use of blackboard and chalk, for he sketched readily and rapidly. I have in my posession notes taken from his lectures in the spring of 1873. They show that many of his illustrations were drawn from local and Brazilian sources—that he brought into his instruction his own observations and experiences. The plan of the course is admirable and so well adapted to student's needs that it could be used as the basis of similar instruction to-day. His lectures were mainly for general culture, his advanced instruction being, for the most part, confined to his laboratory. Here the students were given books and specimens and, after a few brief suggestions as to their use, were allowed to work for themselves. That keenness of insight which guided him, that quality so essential to an original investigator, he expected to be developed by the very nature of the task undertaken. Were it otherwise, the first requisite of a scientific life was wanting.

I have written of professor Hartt as a teacher, for it was as my teacher that I knew him. His career at Cornell ended with his departure for Brazil in the autumn of 1874. With a few personal friends I accompanied him to the top of the Ithaca Z as he left on the train for New York, and there I bade him adieu. Alas, it was a final farewell, as I never saw him again.

II.

Professor Hartt was a native of New Brunswick, having been born at Fredericton on August 23, 1840.* His early instruction was received at Horton academy, Wolfville, Nova Scotia, after which he pursued an advanced course at Acadia college. From early childhood he had shown a marked fondness for natural history, and now, as a college student, he became greatly interested in geology. Having graduated with honor, in 1860, he accompanied his father to St. John, New Brunswick, where they jointly engaged in teaching. Here his interest in geology was again shown by the beginning of a successful exploration of the "fern ledges" on the Bay of Fundy. This exposure of Devonian shales, lying largely between the tide-marks, afforded much material, plant and insect remains,* new to science, the discovery of which added not a little to the already increasing fame of the young geologist. His account of this locality may be found in Dawson's Acadian Geology.† About this time (1863) occurred the most important event in his career, viz., the acceptance of an invitation from Louis Agassiz, the foremost living naturalist, to come to Cambridge as a special student in the great museum he had there established. For three years Hartt labored under the direction of that eminent teacher, spending his vacations in the further investigation of the geology of Nova Scotia and New Brunswick. In 1864 he accepted a position on the Geological Survey of the latter province where, in conjunction with professor G. F. Matthew, he first recognized the Primordial group.

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*For facts and dates, I am, in many instances, indebted to the writings of Prof. Martin, Dr. Branner and Mr. Rathbun, hereafter mentioned.

In 1865 he was appointed by professor Agassiz, one of the geologists of the Thayer expedition, and in that capacity accompanied him to Brazil. On this and a subsequent private expedition in 1867, he accumulated the materials, which, when elaborated, were incorporated in a handsome book of over six hundred pages entitled "Geology and Physical Geography of Brazil." published by Fields, Osgood & Co., Boston, 1870.

In the prefatory note of this work professor Hartt wrote:

"This volume is the result of two journeys made by myself "in Brazil. The first was undertaken under the direction of "professor Agassiz in connection with the Thayer expedition "in the years 1865 and 1866. On this journey I studied very "carefully the geology and physical geography of the coast "between Rio and Bahia, going over a very large part of the "ground on horseback or in a canoe. * * Mr. Copeland and "I made very large collections of marine invertebrates and "fishes, though we did not neglect to secure other objects of "natural history. I hope that these collections will throw "much light on the fresh water and marine animals of the "coast, and, as they were made at frequent intervals between "Bahia and Rio de Janeiro, that they will prove valuable in

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*For many years these Upper Devonian fossils were regarded as the earliest representatives of insect life in the world, a few specimens only having been found, in Europe, as low as the Carboniferous, but late discoveries, in southern Sweden, show that insect-life is there represented as far back as the Lower Silurian.

†See Second Edition p. 513 et seq.

"the study of the distribution of these animals. My studies "of the stone and coral reefs and of the geology of Brazil "proved so very attractive to me that on the year following I "returned to Brazil, and spent my vacation, several months, "in examining the coast between Pernambuco and Rio, exploring more particularly the vicinity of Bahia and the islands and coral reefs of the Abrolhos. * * *

"This volume was intended at first as a report to professor "Agassiz as the director of the Thayer expedition, embracing "simply the results of my explorations as a geologist of that "expedition, together with those of my second independent "journey, both reports to be published among the contributions of the Thayer expedition. During the preparation of "these reports, and in consequence of the delay in publication, "I have had the opportunity of examining more or less critically the works of the majority of the writers on Brazil, and "the volume, from a simple report of my own investigations, "has grown to a general work, in which I have incorporated "the best results of others who have written on the geology "and physical geography of Brazil."

It is scarcely possible to review here with sufficient minuteness a production of so great magnitude—so varied are the topics treated. The author's own studies were confined mainly to the coast provinces, but, as above stated, he carefully compiled, in addition, the observations and conclusions of others, thus giving the subject a wider scope than his own research would permit. Nor are matters of economic importance omitted; for instance, a chapter is devoted to gold mining, and the occurrence of the precious metal in many localities is recorded. There are also notes on the occurrence of diamonds and the diamond-washing industry. The last chapter (XIX) is devoted to a resumé of the geology of the empire, and the volume concludes with an appendix of 30 pages "On the Botocudos," one of the most primitive of the native races. Mention should also be made of the many illustrations in the text and the large sketch map, compiled and drawn by the author himself and reproduced by the Osborne process.

Upon the establishment of the American Naturalist, in 1867, Hartt became a contributor and from time to time, for ten years, furnished papers of unusual interest upon a variety of topics, geological, ethnological and descriptive. His acute and accurate observations were not confined, as in the case of many specialists, to the object directly sought, but everything bearing even remotely upon it was deemed worthy of investigation. And thus it happened that though a professional geologist he has left behind many observations and notes upon the habits of life, burial customs, language and utensils of the native races of South America.

In the first volume of the Naturalist (June and July, 1867) he published a paper on "The Recent Bird Tracks of the Basin of Minas," in which he gave an account of the unique tidal phenomena to be witnessed in the easternmost arm of the Bay of Fundy, the deposits resulting from it, and showed how the tracks of animals, especially birds, and even the imprints of the falling raindrops, are recorded on the mud-flats and, in sheltered situations, preserved.

"From these studies," he wrote, "we must see that the phe-"nomena going on around us must be the Rosetta Stone, which "shall furnish us with the key for the deciphering of the hie-"roglyphics of the Stone Book, and that we shall understand "the results of the forces which acted in the past in propor-"tion as we correctly understand their action in the present."

The opening article of volume II (March, 1868), entitled "A Naturalist in Brazil," is from his pen. He noted here the wonderful geological resemblance between the eastern coasts of Brazil and the United States, and, by means of sections, made clear the relations of the different formations between the mountains and the sea. The evidence of the recent upheaval of the Brazilian coast is briefly mentioned, as for instance, beds of sand containing recent species of shells and rocks containing the nests excavated by sea-urchins, now raised above the high-tide mark.

He also described the Abrolhos islands, their position on the submarine shelf of Brazil; their structure; the decay of their trap-rock covering; and their fauna, both terrestrial and marine.*

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*Professor A. E. Verrill has described a number of new species of corals from this vicinity collected by professor Hartt. See Trans. Conn. Acad. of Arts and Sci., vol. I, pp. 351-371. Some of the descriptions accompany the above paper as notes.

But the most important announcement is that of the existence in this vicinity of true coral reefs. He said: "While "engaged in the late Thayer expedition under professor Agassiz, in company with Mr. Edward Copeland, the writer discovered some quite extensive reefs in the bays of Santa Cruz "and Porto Seguro, and made out, in a general way, their "structure. Fishermen and pilots described the reefs of the "Abrolhos as precisely like those at Porto Seguro, and a note "in a chart of lieutenant Mouchez, which afterwards fell into "the writer's hands, left no doubt of the existence of extensive "coral reefs in that region. The return of the expedition left "no time for their exploration, but the writer, during his visit "to the Brazilian coast last summer, gave them a careful examination. * * *

"The great shelf of the Abrolhos lies, over a very large area, "at a depth of less than a hundred feet, and the conditions "for the growth of corals are of the most favorable kind. "In consequence of this, we find here not only around the "islands, but in the shoal, open waters, very extensive reefs "and banks, which, in an area of fifty miles square, occupy a "space of nearly one hundred and fifty square miles."*

In the April number of the Naturalist, for the same year, (p. 85) under the title "The Cruise of the Abrolhos," he described the reef-grounds of the Abrolhos region, known as the Parêdes, with its mushroom-shaped coral structures, or *chapeiroes* and reefs.

His account of *Recife do Lixo*, with its myriads of living forms, is especially vivid. "The whole reef is alive," he exclaims with an enthusiasm which becomes contagious, and his readers peer with him into the clear pools and behold in strange places many interesting and unfamiliar phases of life.

In 1869 Hartt was honored by an election to the General Secretaryship of the American Association for the Advancement of Science for the Troy, New York, meeting, but when the time came he was conducting another exploration in Brazil, known as the first Morgan expedition.

In his preliminary report† he says: "My expedition to the "Amazonas, in 1870, was undertaken chiefly for the purpose

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*Pp. 9 and 11.

†*Bulletin of the Cornell University, Science*, vol. I, no. 1. 1874.

"of studying the geology of the valley, and of examining the "table-topped hills, which last had been referred to the Drift. "I wished, also, to take into the field a number of scientific "students from Cornell University, in the expectation that "some of them, at least, might be stimulated to devote themselves to the life study of some branch of natural history."

On this expedition he was accompanied by a party of twelve, one of which was his colleague, professor A. N. Prentiss, of the chair of botany. The remainder were chiefly students. Here again that kindly spirit, so characteristic of Prof. Hartt is shown, for no one realized more fully than he that the care, responsibility and training of an inexperienced body was not only a burden, but that it involved a personal sacrifice as well, viz., the loss of much valuable time from his own scientific pursuits. But he expressed no regret at his course; on the contrary, he rejoiced, for, of that little band, several were induced to enter upon scientific careers.

"If," he wrote, "to discover a new Carboniferous fauna will "repay a journey to Brazil, of how much greater importance "is the discovery of a new naturalist? Had the expedition "produced no other results than to have added four new men "to science, I should have considered time and money amply well spent."*

Upon the return of the expedition he published a brief paper, in the *American Journal of Science* for April, 1871, on "Amazonian Drift," in which he set forth his disagreement with professor Agassiz regarding the glaciation of the Amazonian valley. The views of Agassiz may be found in chapter XIII of his "Journey in Brazil."† As epitomized by Hartt they are as follows: "Prof. Agassiz has claimed that the geological structure of the Amazonian valley is very simple; "that, from one end to the other, there were laid down in a "fresh water lake, formed by the damming up of the mouth of "the valley by a glacial moraine, beds of sands, clays and "sandstones, filling the valley to the hight of nearly a thousand "feet above the present level of the river; that, from the bursting of the barrier and draining of the lake, the uppermost "beds were swept off from over a very great part of the valley,

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**Bull. of the Cornell Univ., loc. cit.*

†A Journey in Brazil, by professor and Mrs. Louis Agassiz. Boston: Houghton, Mifflin & Co.

"leaving only isolated outliers as a series of table-topped hills "or serras, like those of Almeirim, Parauáquára, Velha Pobre, "&c.; that the lake reduced to a lower level, then threw down "over the denuded area a sheet of clay, the river finally cutting its channel through this clay and the underlying sands, "etc. He did not claim to have found grooved or striated "surfaces on the Amazonas, and the only supposed erratics he "discovered were the diorite boulders found on the flank of "the Serra of Ereré."

To this Hartt could not give his assent and in the same paper he said: "To speak broadly, I did not see either at "Ereré or in any part of the Amazonas anything that would "suggest glacial action. So far as the province of Pará is "concerned, the clays, sands, etc., forming the lower lands are "far from being uniformly distributed and are very puzzling "to study. The arrangement of the materials varies in different regions, and many of the deposits are local. In part the "lower lands are formed from the material derived from the "wearing down of the great sheet of clays, etc., of which the "Almeyrim and Santarem hills are relics; in part they are of "brackish or fresh water origin deposited when the river stood "at a greater hight; and much is the very recent work of the "river. The variegated clays are not all of the same age. "Superficially examined they appear to be universally distributed, but it is very far from being the case. It is impossible "to recognize and trace beds of clay in the Amazonian valley "with the aid of lithological characteristics alone. It is sufficient to say that variegated clays of exactly the same appearance and structure, because formed of materials which "have been reworked or were originally drawn from the same "source, occur in the Devonian, Carboniferous, Tertiary, and "in half a dozen successive formations of recent times.

"I have referred the beds of the table-topped hills to the "Tertiary. Some of the clays and sandstones of the lower "Amazonas may also be later Tertiary; but many are undoubtedly recent, as they are full of leaves of modern species. "Near Santarem I found a bed of fresh water mussels, *Castalea*, *Hyarea*, *Unio*, etc., whose upper limit was at least fifty "feet above the level of the highest Amazonian floods. This "is in exact accord with the facts I have given elsewhere bear-

"ing on the late rise of the Brazilian coast, a rise which ex- "tended itself into the interior. Before this rise the land stood "much lower than at present; the island of Marajo did not "exist, and the Amazonas formed an estuary opening widely "to the sea. Not only were the lower plains of Pará flooded, "but immense tracts of the province of Amazonas were cov- "ered with water. How far this salt water penetrated I do "not know, but the shells of Pebas show that at one time its "influence may have extended far up toward the Andes. At "the time of the growth of the Santarem shells the water may "have been brackish. With the gradual rise of the continent, "not of the Andes alone, the fresh waters drove down the salt, "the river bed with its numerous side channels was hollowed "out of the emerging bottom, the sea began to attack and cut "away the coast lands, and the present estuary condition of "the mouths of the great river was brought about."

He also showed that the so-called "erratics" at Ereré, where he spent a month, "going over the ground on foot in every direction, and in the most detailed way," to have been derived from a large mass of trap that had "given rise to a great number of boulders of decomposition which lie on the surface, or are buried in decomposed rock. They have often been carried down the beds of torrents, but they are nowhere erratics." Again, in a paper "On the Tertiary Basin of the Marañon," published in the *American Journal of Science* for July, 1872, he expressed his disbelief in the glacial origin of the Amazonian valley.

Knowing Hartt's great appreciation of Agassiz, and the warm personal friendship that existed between them, I doubt not that he felt keenly the necessity of differing so strongly from the views of his eminent teacher. To follow science is to search for truth. To correct error is essential to progress. In this spirit Hartt felt it to be his duty to publish his observations to the world.

In the *American Naturalist* for May, 1871, vol. v, p. 139, he published a paper on "Brazilian Rock Inscriptions," with nine full page illustrations, in which he reproduced some of the so-called hieroglyphics of the Rio Tocantins, near the lower falls, and of the Serra of Ereré, on the north side of the Amazon valley, near Monte Alegre, together with some figures from the Serra of Obidos and the Rio Oyapock, given him by his friend, Senhor Ferreira Penna, of Pará.

The first mentioned figures, which are exposed only during low water, appear to have been rudely chiseled in the rock, a hard quartzite, of a dark red or brownish color. The Ereré drawings have been rudely drawn with a reddish paint, though in some instances that of a dirty yellow color, as well as the red, has been employed. A great variety of objects are represented here: human faces, animals, and probably the sun, moon and stars, etc. "I hold it most probable," said professor Hartt, in the accompanying text, "that the rock painting and sculpturings are made by tribes which inhabited the Amizonas previous to the Tupi invasion. The sculpturings are supposed to be older than the paintings. * * I think the Ereré figures have a deep significance. A people who would go to so much trouble as to draw figures of the sun and moon high up on cliffs on tops of mountains, must have attached a great importance to these natural objects, and I think that these figures point to the worship of the sun by the tribes which executed them. The clustering of the inscriptions in prominent places, and especially on and in the vicinity of the rock tower at Ereré, seems to me to indicate that these places had something of a sacred character, and were often resorted to. Many of the figures seem to be the capricious daubings of visitors, as, for instance, the human faces, drawn on angular rock projections. Some of the animal forms may have had a sacred character."

"I know of no trace of sun worship among the uncivilized Indians of Pará to-day, nor do they make rock paintings or inscriptions. The greater part of the Brazilian Indians, such as the Tupis, the Botocudoes, etc., appear to have no idea of God, and no form of worship."

In the same magazine, for July, he contributed another paper, entitled "The Ancient Indian Pottery of Marajo, Brazil," describing burial jars and idols collected by his assistant, the late Dr. William Stebbins Barnard. This article was illustrated with ten figures on wood.

The second Morgan expedition to the Lower Amazonas was undertaken in 1871. The party was a small one. Mr. O. A. Derby accompanied the professor as assistant, and at Santarem they were joined by Mr. J. B. Steere, of the Michigan University. Returning to the United States, professor Hartt resumed his duties at Cornell in the winter of 1872. The following year he delighted the students with a course of lectures upon invertebrate zoölogy, a synopsis of which, covering sixteen pages, was published by the university press.

May 16, 1871, he read a paper before the American Geographical Society of New York, on "Recent Explorations in the Valley of the Amazons," which, corrected after his return from the above mentioned expedition, was published in the journal of that body for 1872 (vol. III, pp. 231-256, 1873). He here sketched the geology of the region about Monte-Alegre and the Serra of Ereré, giving an account of the discovery of Devonian fossils, and recorded his observations upon the topography, the vegetation, and the soil of the district.

He next discussed the Carboniferous rocks and fossils of the Tapajos, especially those discovered at Itaituba and on the Igarape do Bom Jardim. The latter locality was of unusual interest on account of the prevalence of silicified fossils, among which may be mentioned the interiors of many species of brachiopods.*

In this communication Hartt also gave an account of his visit to the Serra of Parauáquára, maintained the impossibility of the glacial origin of certain Amazonian deposits, and expressed his belief in the more or less local origin of the Pará deposits.

In 1874 he published some of the results of the Morgan expeditions under the following titles:

"Contributions to the Geology and Physical Geography of the Lower Amazonas. The Ereré-Mont-Alegre District and the Table-Topped Hills," in the *Bulletin of the Buffalo Society of Natural Science* for January, 1874.

"Preliminary Report of the Morgan Expeditions, 1870-71," and "Report of a Reconnaisance of the Lower Topajos," both in volume I of the *Bulletin of the Cornell University, Science*, 1874.

About this time he lectured before the Natural History Society, one of the best known student's organizations, upon "Evolution in Ornament." This extremely interesting lecture was afterwards repeated elsewhere, and, in an elaborate form, was finally published in the *Popular Science Monthly* for January, 1875.

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*See paper "On the Carboniferous Brachiopoda of Itaituba, Rio Tapajos, Prov. of Pará, Brazil," by O. A. Derby, M. S. Bull. of the Cornell Univ., vol. I, no. 2, pp. 63; plates VIII.

The interest manifested in his explorations by the emperor of Brazil, and other officials high in authority, led Hartt to hope for governmental aid, and the success of the Geological and Geographical Survey of the Territories, under Dr. Hayden, and the Geographical Surveys west of the 100th Meridian, under Lieut. Wheeler, in this country, stimulated a desire on his part to direct a similar enterprise in the great South American empire. Accordingly, in the autumn of 1874, he went to Rio Janeiro with the intention of establishing, if possible, a geological survey of that country. It has been said that he was invited by the Brazilian minister of agriculture to submit plans,* but Dr. J. C. Branner, who accompanied him, is of the opinion that the trip was undertaken entirely upon his own responsibility.† Be that as it may, he did succeed in establishing an Imperial Survey, and though his plans were greatly curtailed, work began in May or June of the following year (1875).

"In the prime of his early manhood, vigorous in health, active, persevering, enthusiastic, with a reputation in science already well recognized, and with a familiar acquaintance with the country and people that he was now called to serve, Hartt entered on his great career amid the pride and confidence of all who knew him aright. Nor did he fail to sustain his reputation. In the face of many difficulties and perplexities—the jealousies, the ignorance, and the wretched mock-economy, that wear the brain and waste the time of almost every head of great scientific enterprises—he pursued his plans. With his faithful assistants, mainly young men who had been brought forward under his own instruction at Cornell, he explored, collected and wrote, until at last the hand of death stayed his ceaseless activity."‡

In addition to his many duties he accepted, in 1876, the directorship of the department of geology in the National Museum at Rio, but the burden was too great, and, in a short time he was obliged to relinquish it.

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*Rathbun, Popular Science Monthly, vol XIII, p. 233.

†The Cornell Magazine, vol. II, p. 187, note.

‡Professor Daniel S. Martin, in the Proceedings of the Fifteenth Anniversary of the University Convocation of the State of New York, Necrology, pp. 1-27. Albany, 1879.

His first preliminary report, as chief of the geological survey of Brazil—translated from the Portugese by professor Theo. B. Comstock—was published in the *American Journal of Science* for June 1876 (III, XI, pp. 466–472). It deals with a variety of subjects: brief observations on the localities he had visited in person; the work of his assistants, Messrs. Orville A. Derby, Richard Rathbun, John C. Branner, Dr. Elias P. Jordao and Senhor Marc Ferrez, his photographer; the kind and extent of the collections made; and future plans. From it I condense the following: While awaiting instructions, in company with commander E. P. Wilson, he visited the gold district in the southwestern part of the province of Minas Geraes and verified the occurrence of the precious metal in three distinct deposits, viz.,—distributed in more or less irregular veins in Archæan gneiss which is very much decomposed; in the lower part of a red earth which covers this region; and in alluvial deposits of the river valleys.

In July of that year (1875) he established a laboratory at Pernambuco and began a systematic exploration of the vicinity which resulted in the discovery of highly fossiliferous beds of Cretaceous limestone. At the same time he carefully examined the reefs along the coast, which are of two distinct types, coral or calcareous and consolidated sand beaches or siliceous, and partly mapped the reef of Pernambuco, a representative of the latter class. On the following September he conducted a reconaissance along the Sao Francisco river to a point a little above the rapids of Paulo Affonso, which was supplemented by a trip to Serra de Maria Farinha, from the summit of which he was able to form a conception of the topography of the adjacent country—a large part of the provinces of Sergipe and Alagoas, and portions of those of Bahia and Pernambuco. He recognized a plateau of gneiss less than a thousand feet high, on which the rivers run in shallow channels, and from which peaks or serras (serrated ridges) rise abruptly, rarely exceeding 2,500 feet in altitude. In Sergipe and Pernambuco they are usually of gneiss or related rocks, while in the provinces of Bahia and Pernambuco, in the region of the Sao Francisco river, there are large serras and table-lands of sandstone, a formation he believed to have once covered this entire region. He also noted the extraordinary erosion effects on gneiss, produced by transported sands and stones, at the rapids of Paulo Affonso—the formation of innumerable pot-holes, their communication with one another, and the final excavation of the rock in consequence.

Most of his papers, writen while he was in Brazil, were published in Portugese, but the following were printed in English: "Notes on the manufacture of Pottery among Savage Races," 1875; "Amazonian Tortoise Myths," 1876.

In June, 1877, the work of the survey was suspended. How great was Hartt's disappointment none but his closest friends can tell. That it wore upon him seriously there can be no doubt. In the spring of 1878 he fell ill, dying rather unexpectedly on the 18th of March, at the comparatively early age of thirty-seven years and seven months. It was reported that he was a victim of that terrible scourge, yellow fever, then raging in Rio, but, according to Dr. Branner, the attending physician expressed the opinion that his death resulted from congestion of the brain.*

The following extract from his last report covering the interval between July 1, 1877 and January 1, 1878, will give a notion of his great activity and serve to show how the closing months of his eventful life were spent.

"The Geological Commission of Brazil found itself, on re-"turning from the field, with an immense mass of most valu-"able material, for the most part new, and without a scientific "library, without access to museums and separated by an "ocean from specialists in its various departments. The idea "of working up palæontological and geological results under "these conditions and of presenting reports on a par of ex-"cellence with those of other geological commissions would "seem utopian to foreign scientific men, and I should never "have undertaken the work had not my knowledge of the "country enabled me to foresee results and to prepare myself "and my assistants beforehand for the probable work before "us. Except for several years of preparatory work in the "United States, the consulting of the best libraries and mu-

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*See Article: "Professor Hartt in Brazil" by John C. Branner. The Cornell Magazine, vol. II, p. 188.

"seums and the taking of advice of scientific men eminent in "specialties likely to be of use in Brazil, and but for the fact "that each man came to his work furnished with abundant "notes and books it would have been impossible to have done "more than prepare mere broad descriptions of the parts of the "country explored and anything like the critical study of fossils "and the accurate determination of formations would have "been absolutely impossible. All this preliminary work, so ex-"ceedingly important to the Geological Commission, has cost "nothing to government. Instead of being forced to send "collections to foreign scientific men for study, the Geological "Commission has been able, in its own laboratories and with "its own resources, to prepare for publication a very consid-"erable part of its results, though this work has naturally "progressed much more slowly than it would have done under "superior advantages. My great desire has been to lay a firm "foundation for Brazilian geology in the development of palæ-"ontological localities and the accurate determination of "characteristic formations by means of fossils, and to this "end the Commission has labored with a degree of success "surprising even to myself, and we find ourselves to-day with "an *embarras de richesses.* The Commission as at present "constituted comprises only six persons, on whom has fallen "all this work of collecting, arranging, and studying this ma-"terial, which in richness is to be compared with that of the "'Thayer,' or 'Hassler,' or 'Challenger' expeditions; and it is "not reasonable to expect that, without free access to scien-"tific libraries and to collections for comparison, the work of "the Brazilian Commission should go on more rapidly than "that of the foreign commissions where the material is divided "up among dozens of specialists and where the scientific man "enjoys every advantage. As it is, it will be several years be-"fore the full results of these commissions are prepared for "publication. For six persons to unpack, assort, prepare, and "describe the immense collections made by the Geological "Commission in less than one year was an absolute impossi-"bility, as every scientific man will agree with me, and in the "six months generously granted me after the suppression of "Commission by the Camaras I had only the hope of saving "as large a fragment as possible of our results. It is needless "to say that it has been entirely out of our power to finish "the work, notwithstanding that the members of the Commission have worked unceasingly day and night on their herculean task. Neither is the discussion of the material finished, "nor are the collections fully determined or arranged. Everything possible has been done, but the work is not ended."*

His career in Brazil has been summarized by Mr. Rathbun, his student, assistant and friend, in these words: "Hartt's "greatest achievement in Brazil was probably his solution of "the structure of the Amazonian valley. It was founded on "the best of palæontological evidence which proves the existence of an immense palæozoic basin lying between the metamorphic plateau of Guiana on the north, and that of central "Brazil on the south, and through which flows the river Amazonas. Silurian, Devonian and Carboniferous rocks make "up the series in regular succession, and in many localities "are highly fossiliferous. He has explained the character of "the isolated Cretaceous deposits, mostly discovered by himself, existing along the coast from Pará to Bahia, and of the "Carboniferous and other regions south of Rio. He has "shown us the manner in which the rocky structure of Brazil "was built up, and has done much toward solving the relations of the crystalline rocks which compose by far the "larger portion of its surface. He has explored the shell-heaps, burial-mounds, and other relic-localities of prehistoric "tribes from far up the Amazonas to the southernmost coast "province. We owe to him also the first real satisfactory explanation of the reefs of Brazil, which he distinctly shows "to be of two kinds—sandstone and coral. He spent much "time in studying the customs and languages of the modern "Indian tribes of the Amazonas and Bahia, and collected very "much material toward a grammar and dictionary of the "Tupi Indian language in several of its dialects. * * In "connection with the Geological Commission of Brazil he "founded a large museum in Rio de Janeiro, which will always bear testimony to his great final undertaking."†

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*Proceedings of the Boston Society of Natural History, vol. XIX, pp. 357-358.

†Sketch of Professor C. F. Hartt, by Richard Rathbun. *The Popular Science Monthly*, June, 1878.

To this may be added the following from Dr. Branner:—"It "is not difficult to sum up Hartt's influence upon geological "work in Brazil, for with very few exceptions all the work of "this character which has been done in that country since "1874 is traceable, either directly or indirectly, to the impetus "given it by Hartt. For the most part the work has been "done by some of Hartt's students and assistants, and as he "was not a narrow specialist, but a broad minded natural-"ist, his students have also done other than purely geological "work. * * *

"But Hartt's good influence has done even more for Brazil "in keeping up the tone and character of scientific work than "in the results thus far published. A country situated as Bra-"zil is, far removed from the centres of scientific activity, is of-"ten the prey of the grossest forms of scientific charlatanism. "Hartt and his assistants naturally came in contact with this "class of men, but he so impressed the leading men of the "empire with his ability and integrity that charlatanism was "never able, in his presence, to make much headway."*

Finally one cannot fail to be impressed with Hartt's phenomenal success as a teacher. His connection with Cornell University scarcely reached ten years (fall of 1868—spring of 1878), of which less than six were spent in actual service. Yet, in that brief interval, he inducted to scientific careers a surprisingly large number of young men who, now in the prime of their usefulness, bear witness to the far-reaching influence of their eminent teacher.

His widow, Mrs. Lucy L. Hartt, of Buffalo, N. Y., a son and a daughter survive him.

List of the Published Writings of Ch. Fred. Hartt, M. A., First Professor in Cornell University.

1864.

1. The gold of Nova Scotia, of Pre-Carboniferous age. Canadian Naturalist, vol. I, pp. 459-461.

1865.

2. Preliminary notice of a fauna of the Primordial period in the vicinity of St. John, N. B. Bailey's observations on the Geology of Southern New Brunswick, pp. 30, 31: also Canadian Naturalist, vol. II, pp. 318-320; and Dawson's Acadian Geology, 2d edition, London, 1868, pp. 641-643.

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*The Cornell Magazine, loc. cit. pp. 191-192.

3. On the Devonian plant locality of the "Fern Ledges," Lancaster, New Brunswick, with a detailed section, and notes on the fossils. Bailey's observations on the Geology of Southern New Brunswick, pp. 131-141. (Includes Scudder's report on Devonian insects.) An abridgement of this appeared in Dawson's Acadian Geology, 2d edition, under the following titles:

3*a*. Section of the "Fern Ledges," near St. John (N. B.), pp. 513-516.

3*b*. Section of the Little River Group at the "Fern Ledges," Lancaster, N. B., pp. 516-523.

4. List of New Brunswick fossils. Bailey's Observations on the Geology of Southern New Brunswick, pp. 143-147.

1867.

5. The recent bird tracks of the basin of Minas, (Nova Scotia). American Naturalist, vol. I, (June), pp. 169-176; and (July), pp. 234-243.

6. On a sub-division of the Acadian Carboniferous Limestones, with a description of a section across these rocks, at Windsor, N. B. Canadian Naturalist, vol. III, pp. 212-224. [For summary of this paper see Dawson's Acadian Geol., 2d ed., pp. 279-280.]

7. Naturalist in the West Indies, [unsigned; supposed to have been written by professor Hartt]. New York Tribune, Nov. 7.

1868.

8. A vacation trip to Brazil. American Naturalist, vol. I (Feb.), pp. 642-651.

9. A naturalist in Brazil. American Naturalist, vol. II (March), pp. 1-13.

10. The cruise of the "Abrolhos." American Naturalist, vol. II, (April), pp. 85-93; one cut.

11. (Descriptions of Acadian fossils.) Taken from the MS. of professor Hartt. Dawson's Acadian Geology, 2d edition, pp. 643-657.

12. Resumé of a lecture on "The Growth of the South American Continent." The Cornell Era, Ithaca, N. Y., December 12; reprint, pp. 8.

1869.

13. A chapter on Cuttle fishes. By Lucie L. Hartt. [The facts were drawn from one of professor Hartt's note books.] American Naturalist, vol. III (July), pp. 257-261; 1 cut in text.

14. On the Botocudos of Brazil, abstract. Proceedings of the Amer. Asso. for the Advancement of Science, 18th meeting, pp. 273-274.

1870.

15. Geology and Physical Geography of Brazil, Thayer expedition, 8vo., pp. xxiii, 620; large sketch map; 73 illustrations in text. Boston: Fields, Osgood & Co.

1871.

16. Discovery of Lower Carboniferous fossils on the Rio Tapajos, [a letter]. American Naturalist, vol. IV (Jan.), pp. 694-695.

17. Amazonian drift. American Journal of Science, III, vol. I (April), pp. 294-296.

18. Devonian rocks in the Amazonian valley. American Naturalist, vol. V (April), pp. 121-122.

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19. Brazilian rock inscriptions. American Naturalist, vol. v (May), pp. 139-147; 9 plates; 1 cut.

20. The ancient Indian pottery of Marajo, Brazil. American Naturalist, vol. v (July), pp. 259-271: 11 cuts in text.

21. Discovery of Mastodon remains at Mott's Corners, near Ithaca, N. Y. American Naturalist, vol. v (July), pp. 314-315.

1872.

22. On the Tertiary basin of the Maranon. American Journal of Science, III, vol. IV (July), pp. 53-58.

23. On the occurrence of face urns in Brazil. American Naturalist, vol. VI (Oct.), pp. 607-610; 1 plate.

24. Notes on the Lingoa Geral, or modern Tupi of the Amazonas. Trans. of the Amer. Philolog. Assoc., p. 20.

1873.

25. Recent explorations in the valley of the Amazonas, with map. Journal of the American Geographical Society of New York, vol. III, 1870-71, pp. 231-252.

26. (Recent explorations of the eastern part of the basin of the Amazonas.) Proceedings of the Boston Society of Natural History, vol. xv, pp. 153-154.

27. Synopsis of lectures on Zoölogy, delivered in the Cornell University during the winter trimester, 1872-73. Ithaca, at the University Press, 1873, pp. 16.

28. O Mytho do Curupira. Aurora Brazileirá, Ithaca, N. Y., Oct.-Nov.; also separate, pp. 12.

1874.

29. Morgan expeditions, 1870-71. Contributions to the geology and physical geography of the lower Amazonas. The Ereré–Monte-Alegre district and the table-topped hills. Bulletin of the Buffalo (N. Y.) Society of Natural Science, Jan., pp. 201-235; 10 cuts, including sketch map.

30. Preliminary report of the Morgan expeditions, 1870-71. Reconnaissance of the Lower Tapajos. Bulletin of the Cornell University, Science, vol. I, no. 1, pp. 1-39: with map.

1875.

31. Evolution in ornament. Popular Science Monthly, vol. VI (Jan), pp. 266-275; many illustrations. Reprinted in Portuguese as "A Origem da Arte ou a Evoluçoa da Ornamentaçao." Arch. do Mus. Nac. do Rio de Janeiro, vol. VI. 1885, pp. 95-108; see also Proceedings of the 10th Anniversary of the University Convocation of the State of New York, Albany, 1874.

32. Relatorio preliminar de trabalhos da Commissao Geologica na Provincia de Pernambuco. Rio de Janeiro, 8vo, pp. 11.

33. Indian cemetery of the Gruta das Mumias, southern Minas Geraes, Brazil. American Naturalist, vol. IX (April), pp. 205-217; 1 cut.

34. Morgan expeditions, 1870-71. On the Devonian trilobites and molluscs of Ereré, province of Pará, Brazil. (With Richard Rathbun.) Annals of Lyceum of Natural History, New York, vol. XI (May), pp. 110-127.

35. Amazonian tortoise myths. Rio de Janeiro: Wm. Scully publisher, pp. 40.

36. Notes upon the manufacture of pottery among savage races. Rio de Janeiro: Office of the South American Mail, pp. 70. Reprinted with the same title, but in a slightly abbreviated form, in the American Naturalist, vol. XIII (Feb.), pp. 78-93; also in Portuguese as "Apontamenta sobre o Fabroco da Louça de Barro entre os Selvagens." Arch. do Mus. Nac. do Rio de Janeiro, vol. VI, 1885, pp. 63-94.

1876.

37. Exploraçœs Scientificas. I. Commissao Geologica do Brazil. Cataloga da Exposiçao de Obras Publicas do Ministerio da Agricultura. Rio de Janeiro, pp. 95-106.

38. Nota sobre Algumas Tangas de Barro cosido dos Antigos Indigenas da Ilha de Marajo. Archives do Museu Nacional, vol. I, no. 1, pp. 22-25; 3 plates.

39. Descripçao dos Objectos de Pedra de Origem Indigena conservados no Museu Nacional. Archivos do Museu Nacional do Rio de Janeiro, vol. I, nos. 2-3; pp. 45-53; 2 plates and 2 cuts.

40. The Geological Survey of Brazil. First preliminary report made to the Councellor Thomas José Coelho de Almeida, Minister and Secretary of State for Agriculture, etc. Translated from the Portuguese by Theo. B. Comstock, assistant professor in charge of the Geological Department of Cornell University. American Journal of Science, III, vol. XI (June), pp. 466-473.

1878.

41. (Report July 1, 1877-Jan. 1, 1878.) Quoted by Rathbun. Proceedings of the Boston Society of Natural History, vol. XIX, pp. 356-362.

1885.—POSTHUMOUS.

42. Contribuiçœs para a Ethnologia do Valle do Amazons. Archivos do Museu Nacional, vol. VI, pp. 1-174.

School of Geology, University of Texas, December, 1896.

1896.

43. A Geologia do Pará. Por Ch. F. Hartt. Reprint of a report written for the editor of the Diario do Gram Pará in 1870, at Pará, Brazil. Published in the Boletim do Museu Paraense, vol. I, no. 3, June, 1896, pp. 257-273, with foot-notes by Dr. E. A. Goeldi.

Note.—This article was probably published in the Diario do Gram Pará in 1870 just as Hartt was returning to the U. S., but the note with the reprint does not give the exact date, and it does not even state positively that it was so published. J. C. Branner.

THE GALENA AND MAQUOKETA SERIES.

By F. W. SARDESON, Minneapolis, Minnesota.

(Plates IV and V.)

Part III.

ON ORTHIS TESTUDINARIA.

It has been claimed by Beecher and Clarke that the very small young shells of the genus *Orthis* are not distinguishable by any specific characters, "that the diagnostic characters of species of this genus may not be assumed until the earlier stages of the shell have passed."* It is further remarkable that the cited observation was made by these authors more particularly concerning the shells of *Orthis elegantula* Dalman and *O. hybrida* Sowerby, notwithstanding the fact that the shells of those species at 2.5 mm, or even at 0.5 mm, are easily distinguishable by their plication alone, provided one does not mistake the dorsal (brachial) valve of *O. hybrida* for the ventral (pedicle) valve. Plicated, bilaterally symmetrical shells like that of *Orthis* have one plication or interplication falling in the median plane in each valve, oftenest the one valve having a median plication, the other a median interplication, and small shells of *Orthis hybrida* Sowerby are distinguished from those of *O. elegantula* Dalman in that, by the former the dorsal valve, by the latter the ventral valve only has a median plication. No one seems to have noticed that difference until now.

The distinction just mentioned came incidentally to my notice while engaged in tracing some of the progressive series of variations in some Galena (Trenton) and Maquoketa (Hudson) fossil species. It has been observed, too, that the described difference between the two Silurian species *Orthis* (*Rhipidomella*) *hybrida* Sow. and *O.* (*Dalmanella*) *elegantula* Dal. can be traced from an origin, apparently in the *O.* (*Dalmanella*) *testudinaria* auct., of the upper Ordovician system. The varieties of *O. testudinaria* bear a very instructive relation to each other and to the two named Silurian species, and that relation described in connection with the geologic occurrence of each will, I think, be worth presenting in the following discussion.

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*Beecher and Clarke, Memoirs of the New York State Museum, vol. I. No. 1, p. 13, 14, and 17.

The writer's intention is to present here an analysis of *Orthis testudinaria*, describing the different forms and noting their geologic relations, in order to establish the same as partial evidence to be used in a later discussion on the question of relative interval during and between sedimentary divisions of the Galena and Maquoketa series. *Orthis testudinaria* auct. in America is no species at all, but this or that or several mixed together. It is *O. emacerata* Hall, or *O. multisecta* Meek, or *O. meeki* S. A. Miller, or other similar species, which are all separated by observable differences without known intermediate connection. I shall for convenience first describe them collectively as

Orthis testudinaria auct.*

All have a convex ventral (pedicle) valve with a low median fold and an acute curved beak. They have a more or less convex dorsal (brachial) valve with a shallow median sinus and a beak that scarcely projects. The shell of each valve consists of several attached parts (fig. 17, pl. IV), forming a remarkably adaptive mechanical structure. The parts are:

1. An outer thin layer (epidermis) that grows at the margin of the shell only. It grows at an equal rate along the whole hinge and hence the flat areas, but from the extremity of the hinge to the central anterior margin of the shell the rate of growth was increasingly greater. The growth of this layer determined the general outline and convexity of both valves, the folds and sinuses and the plications.

2. A layer within the first is composed of prisms or "fibres" of calcite, that are directed obliquely forward and inward with respect to the whole fossil. They are based against the epidermis and end upon the inner surface of the layer. The growth was not at the edge of the shell, but upon all the inner surface outside the area of the muscle scars, (visceral area). Its tendency is to completely even up the inequalities or plications, so that these in mature shells nearly all disappear from the inner surface, being, however, apparently reproduced partly anew in senile, very thick shells, in the same, seldom in a new direction. This layer is punctate, threads of the

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*For general citations see Davidson's Monograph of British Silurian Brachiopoda, p. 226; Winchell and Schuchert, Geological and Natural History Survey of Minnesota. final rep., vol. III, p. 441, 445.

mantle having penetrated it as in recent Brachiopoda, because, as I should guess, points of the mantle adhered to layer number one, number two growing around them. 3. On the ventral valve are the dental lamellæ. They are impunctate, and are built from the beak forwards and upwards, the base only being imbedded in the punctate layer. Their apices are the teeth or articulating projections. 4. On the ventral valve between the "dental lamellæ" is also a pedicle callist to the posterior surface of which was attached the pedicle, as the muscles were attached to the posterior surface of the other layer upon which the pedicle callist mainly rests. This part, too, grows at the anterior slope of its inner surface. It is situated really in the beak of the valve. On the dorsal valve are similar parts, viz.: 5. The septum, which is not always distinguishable from the main punctate layer upon which it rests, fills the dorsal beak and extends forward between the adductor muscle scars. 6. Upon the posterior end of the septum, like a bent over part of the same, sits the impunctate cardinal process, which, as well known, formed on its posterior surface the attachment for four divaricator muscles, and which correspondingly is theoretically divisible into four coalesced parts. The median two parts extend beyond the other two, giving an outwardly tripartate division of the end of the process (fig. 8, pl. IV). The length of it varies directly with the convexity of the two valves, in individuals as well as between varieties. 7. The cruræ upon either side of the cardinal process vary likewise in length, are impunctate and coalesce with the cardinal process at their bases. 8. Small deltidial plates are rarely preserved.

The place of attachment of muscles to the shell is marked by corresponding depressions, since under the attached ends of muscles no shell seems to have been deposited, and perhaps even reabsorption took place. As the animal grew the muscle attachments moved forward, leaving tracks that in part trailed over each other and that in turn became covered by processes of the shell advancing over them. There are always the four deep adductor muscle scars on the dorsal valve, of which the anterior pair are the larger. Of the eight muscle scars on the ventral valve the posterior or accessory divaricators are seldom to be seen, and the two adductors form one central scar, anterior to which are divaricators, and to either side the pedicle adjustors (see fig. 18, pl. IV).

The muscle scars vary in size and position in individual specimens, and the trailing of one over the other at an unequal or changing rate and in slightly different directions produce individual differences that are often far more conspicuous than the real varietal or specific ones. The depth of the scars is greater in periods of retarded growth of the animal and is variable. Vascular sinuses are rarely seen and ovarian spaces are rare on the ventral valve. The foramen is a triangular delthyrium. The corresponding notch in the dorsal valve is nearly blocked by the cardinal process.

The exterior surface of the valves bears plications and they are characters, as said, of the epidermal shell layer. They remain nearly uniformly coarse after having attained a certain size, and increase in numbers, their growth being thus the reverse in manner from those of *Orthis*, in which the number of plications remains constant while the size increases. The few primary simple plications of small valves increase, by branching, i. e. along the side of a large plication begins a mere raised line, which enlarges gradually to full size. The one valve is the reverse of the other, inasmuch as the plications of the one correspond to interplications on the other.

As to the distinction of varieties and species the internal characters of this group of shells are not more constant than their mere outward form and plication, and there is no reason why the latter conveniently accessible characters could not be used alone for identification, and especially so since the external and internal markings will be found to vary dependently.

The external characters are even the more reliable, because more often accessible for study than are the interiors, and because the latter are confused from the crossing and trailing of one scar over the other and by differences due to age of the individual and to interrupted growth periods, while the external characters suffer only from injury to cardinal angles and from absorption of the outer shell layer from the older surface of the shell, and in such manners as are easily accounted for. The muscle scars, too, on separated valves are not rarely changed to an unnatural outline by maceration and again by weathering, and such changes are not so easily detected as obliteration of the plicated outer surface.

It requires a large collection to aid in distinguishing specific or varietal characters from the individual peculiarities, although there is an additional assistance in certain abnormal or occasional specimens which present instead of the two normally symmetrical parts on the right and left of the median plane, two extremes of development nearly equal to the differences in any two separate individuals of the variety or species. And that is true of both the internal and the external features of the shells.

Orthis testudinaria auct. includes the following species:—

ORTHIS ROGATA Sardeson.

Pl. IV, fig. 1 to 10.

Orthis rogata Sardeson, (Apr. 9, 1892). Extr. Bull. Minnesota Academy Natural Sciences, vol. III, p. 331, pl. 5, fig. 1 to 4.

Orthis testudinaria Hall, (1892). Pal. N. York, vol. VIII, pt. 1, pl. 5 B, fig. 27 to 31.

Orthis (Dalmanella) hamburgensis W. and S. (1893). Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. III, p. 440, pl. 33, fig. 14 to 16.

Orthis (Dal.) testudinaria W. and S. Loc. cit. p. 441, pl. 33, fig. 17 to 22.

This shell is found in the Upper Mississippi valley in the Ordovician strata, ranging from the top of the Stictopora bed (4) to the Lingulelasma bed (8), and is very abundant in the Fucoid (5) and Orthisina (6) beds.

It is small and has a subcircular outline, the hinge line two-thirds to three-fourths the greatest width of the shell, and the cardinal angles broadly rounded. The ventral (pedicle) valve is convex and the dorsal (brachial) valve nearly plane, but the convexity of both is often much beyond the normal condition. Aged specimens generally are very strongly and irregularly convex near the margin of the valves and dorso-ventral growth at the shell margins may mark the final stage of shell-building. In such cases, concentric lines, which seem to be only from interrupted growth of the animal, are numerous. Concentric lines occur at any stage of growth of the shells however. Dwarfed specimens show great convexity, as a rule. Spiniform cardinal angles are an accidental character. On young specimens the ventral valve has a median ridge or fold and the dorsal a corresponding depression or sinus, but both and particularly the latter vanish toward the margin in the mature grown shells. Both the acutely curved beak of the ventral valve and the obtuse and nearly straight one of the dorsal have been shortened by etching or erosion on the senile shells. The cardinal area of the ventral valve is about three times as high as that of the dorsal. The cardinal process is small, but variable in length. A strong rounded septum extends between the dorsal adductor scars to a little forward of the same. The scars are strongly marked, the anterior pair being the larger. Some greatly thickened shells have ridges extending obliquely forward from the crura, and thickening along the vascular spaces, both of which tend to obscure the outline of muscle scars. The ventral muscle scar area is surrounded by strong ridges that join the bases of the dental lamellæ. Very often there is a thickening in the cardinal angles and on it are furrows that coincide oftenest but not always with the direction of the external plication.

The outer surface has angular plications transverse to which the shell is finely marked like *O. emacerata* Meek.* The plications on the ventral valve on the smallest specimens found have already increased to eleven, of which nine seem to rise from the beak and two from the cardinal margin near the beak. These branch three or four times more in mature shells making about 80 or 120 in all. The median plication is on the ventral valve. On each valve the plications may be classed into eleven fascicles, corresponding to the eleven plications of the ventral valve. The offset plications in general appear alternately on the anterior and posterior sides of the older plications, but in the median and next two pairs of fascicles those branching toward the median line or forward are reduced in number by omission.

In the median fascicle the offsets from the median plication are paired, but under the conditions of dwarfish growth they appear alternatingly, or at least the number of plications is reduced in small-sized mature specimens.

The dwarfish smaller mature individuals have proportionately larger visceral areas, or rather the circumference of their valves is proportionately shortened. The same are more convex than larger specimens and in connection with the greater convexity there are variations in the crura and in the plication. The whole number of variations in this species can therefore be approximately referred to one, viz., the variation in proportionate length of mesial circumference, and of this variation the described variation in plication of the valves is the clearest, most trustworthy index. In discussing the branching of the plications we have all the essential variations of this species indirectly taken into account.

The extent of the variation of this one feature is as follows. The primary plications and their branches give off branches alternatingly, except the median one which sends off two or three pairs, and except that secondary branches rarely give paired branches also. This stage is seen in large, symmetrical, flat specimens, while variation from it obtains to the extent that in small, convex, senile shells alternating branches only are given off by the median plication also, and farther that no branch may appear between the median and its first offset so that they are practically paired for the part of their length. The relative time at which drawfish growth was induced is inconstant, but in cases where it was very early, the pairing of the first offset with the median plication is all but complete. Of course all offset plications are retarded by the relative shortening of the shell's circumference, but one sees it best in the median fascicle where paired, nearly paired, nearly alternating, to alternating offsets, to nearly paired offset and median plication obtains. The bilateral symmetry of the shells may be cited as the probable reason why the median plication normally has paired offsets instead of alternating ones like the other primary plications, and again after the exact bilateral symmetry has been disturbed to an alternating arrangement by dwarfing; the subsequent pairing of the median with its first branch may be explained as restoration of bilateral symmetry merely. Not always has dwarfing of the shells disturbed bilateral symmetry of the plication, but as a rule it has, and the retardation of the branching is manifest now upon the right or again upon the left side of the median plication.

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*See Pal. Ohio vol. I, pl. 8, fig 2g and 3d.

As will be seen later the variation in *O. rogata* Sardeson is in the direction from the characters seen in *O. emacerata* Hall towards those seen in *O. multisecta* Meek of the Hudson epoch.

ORTHIS MULTISECTA Meek.

Pl. IV, fig. 20 to 23.

Orthis emacerata var. *multisecta* (James) Meek (1873). Palæontology of Ohio, vol. I, p. 112, pl. 8, fig. 3a, b, c, d.

This species should not be called a variety of *O. emacerata* Hall. It is the type of a very different variety of '*O. testudinaria*' from that one. It is found associated in Cincinnati, Ohio, with both *O. emacerata* Hall and *O. meeki* S. A. Miller, to the latter of which it is the more nearly related.

O. multisecta is a little larger than *O. rogata*, is often as finely striated, but has a pair of primary median plications instead of one on the ventral (pedicle) valve; and the median fascicle of plications is therefore divided into two. The plications branch about three times between the beak and the margins, but in the median a pair of fascicles sometimes only twice, while again one or both median plications may branch into the median furrow and there may thus be from 4 to 9 plications in one or both of the median fascicles, the number and fineness of them varying in that manner.

The shell is round anteriorly and laterally, but the position of the hinge is such that the shell's length is less than its breadth. The cardinal length varies from one-half to two-thirds the width of the shell. The ventral valve is deep and has the convexity greatest near the median line, while the dorsal valve is nearly flat with a deep, broad median depression expanding and deepening from the beak to the margin. The shell is thin unless thickened with age. The shell structure and the internal characters are nearly like those of *Orthis rogata*.

The relationship between *O. rogata* and *O. multisecta* is expressed no doubt in the very great similarity between them. The former is the predecessor and could perhaps be the parent species, since it is found in beds 1 to 7, while *O. multisecta* is found rarely in bed 12 in Iowa, and very abundantly at an equivalent horizon and higher in the Cincinnati group of Ohio. But it is the dwarfish, convex, small individuals of *O. rogata* that verge toward *O. multisecta*, notwithstanding that the latter species is the larger, and we find that it is the relative proportion between the mesial periphery and the convexity of the shell, or the same expressed in the manner of plication, in which the agreement consists. In these respects the *O. multisecta* Meek appears like a resultant from the variation noted in *O. rogata*.

A theory to explain the origin of the double median plication of the ventral valve and of the single dorsal median plication, can be constructed as follows: that the variation of the median plication with paired offsets to the same with alternating offsets, and to one with the first one of the latter paired with the median itself, as seen in *O. rogata*, has gone still farther owing to early dwarfing of all individuals, and the completely paired median plications of the ventral valve of *O. multisecta* resulted. (See figs. 29 a–d pl. V.)

This character having been transmitted by inheritance is retained in even these larger shells which returning favorable conditions have produced. Corresponding to the change in the ventral valve an inverse change in the dorsal obtained. The dorsal valve is less convex, the ventral more convex than the same in the average of *O. rogata.*

Variation in *O. multisecta* is noticeable, in particular that one of the paired median plications is sometimes the smaller, or, on the contrary, one or both at a late stage of the shell's growth give off a small branch into the furrow between the two. Really dwarfish specimens of this species are probably not found.

ORTHIS MEEKI S. A. Miller.

Pl. IV, fig. 24 to 29.

Orthis emacerata Meek, (1873), Palæontology of Ohio, vol. I, plate 8, fig. 2a-g, (non Hall).

Orthis meeki S. A. Miller, (1875), Cincinnati Quarterly Jour. of Sci., vol. II, p. 20.

Orthis (*Dalmanella*) *testudinaria* Hall, (1892), Palæontology of New York, vol. VIII, pt. 1, pl. 5 B, fig. 32-37.

Specimens of *O. meeki* of small size, but apparently immature ones, have been collected at Cincinnati, Ohio, at about 200 feet elevation above the Ohio river. Larger ones have been received from Oxford and Lebanon, Ohio, and Madison, Indiana. The vertical range may therefore be said to include the whole upper half of the Cincinnati series, at least. It is not yet known in the area of the Maquoketa series. It is associated with *O. multisecta* Meek.

Orthis meeki is larger, hence more loosely plicated than *O. multisecta* Meek, but the plication is, in general, alike. *Orthis meeki* is less convex, and has a stronger median fold and sinus than the other, and is easily mistaken for *O. emacerata* Hall, from which, however, it has a quite different plication and surface ornamentation. The interior of the valves, so far as seen, are very much like *O. multisecta*, but the thickening of the shell makes deeper muscle scars on the dorsal valve, and a narrower muscular area of the ventral valve. I have found no transitional connection between *Orthis multisecta* Meek and *O. meeki* S. A. Miller, and although such have been believed, by authors, to exist, still the same informants confuse also *O. meeki* with *O. emecerata* and *O. corpulenta*.

Our theory regarding the origin of the double median plication in *O. multisecta* appears to fall unsupported in *O. meeki*, unless it be assumed that this one was earlier derived from an *O. multisecta*-like form, having become larger and more extended in the meantime than that one. Of the two, *O. meeki* is the less convex, and has correspondingly additional plications, especially those between the paired median ventral plications being earlier and oftener developed.

ORTHIS IGNOTA n. sp.

Pl. v, fig. 1 to 7.

In the Wykoff formation, in bed 13, are found in southeastern Minnesota, many shells of a superficial resemblance to others (*Orthis corpulenta* Sardeson), with which they are associated, but which are still so distinct that no confusion of the two species is found even in a single specimen among several thousands examined. It is similar to *O. multisecta* or *O. meeki*.

This species is quadrangular rather than circular in outline and is broader than long. The cardinal line is always shorter than the width of the shell. The ventral valve is convex while the dorsal valve is nearly flat. On the ventral valve a longitudinal depression on either side of the median line bounds the median convexity, but the same may be entirely reduced at the anterior margin. On the dorsal valve a corresponding median depression which gradually expands from near the beak does not disappear with advanced growth nor does the raised portion on either side of it. Accompanying this manner of development the anterior margin is necessarily straightened or indented. As in most "*O. testudinaria*" seen, a division into five radial surfaces on each valve is found, and of these three on the dorsal valve are concave or flattened and two intermediate ones are convex. The unequal development of these divisions produces the suggestion of quadrangular outline in *O. ignota*.

The beak of the ventral valve is curved in towards that of the dorsal valve. The latter is straight. The area on the ventral valve is scarcely twice as large as on the dorsal and the triangular foramen is nearly closed by the cardinal process from the dorsal valve. This cardinal process when well preserved is posteriorly strongly tripartate, and has the central part much the most developed. The crural plates reach downward nearly to the ventral valve.

The rounded septum between the muscle scars on the dorsal valve is smaller than in *O. corpulenta* and the adductor muscle scars are not surrounded by elevated callists but are simply depressed surfaces deepest posteriorly. There is a ridge, however, between the anterior and posterior pairs. The anterior pair of adductor scars are much the larger. The muscle scars of the ventral valve are conspicuously large, and extend far forward. The oblong divaricator scars are close together and between and behind them is an elliptical adductor scar, on either side of which is a large oval adjustor scar. Close to the pedicle attachment scar are two small accessory adductors faintly marked. The pedicle attachment is large and distinct.

The ventral valve has a double instead of single median plication, and an analysis into six pairs of fascicles of plications as in *O. multisecta* is found to be constant. The number of plications in the median pair is variable, and often one of these is the extreme of its mate in this character, as in the specimen figured (fig. 3, pl. V). A slight convergence of the plications near the anterior margin is common.

From *O. corpulenta* with which this form has been confused, the double instead of single median plication on the ventral valve, the finer plication, the more quadrangular outline, and the large-sized muscle scars, make a good distinction. The last character separates this from *O. multisecta* and *O. meeki* but in other respects it generally resembles either the one or the other of them. It is the successor to *O. multisecta* in the Maquoketa series, but it is contemporaneous in part with that one because the same did not become extinct elsewhere. With *O. meeki* S. A. Miller it certainly lived contemporaneously, as far as known. Its origin might be from earlier representatives of *O. meeki*, slight dwarfing having produced finer plication and convergence of the same, with shortening of the mesial periphery, especially at the anterior of the valves.

ORTHIS TERSA Sardeson.

Pl. v. fig. 8 to 13.

Orthis tersa Sardeson (1892) Bull. Minnesota Academy Nat. Sci. vol. III, p. 331, pl. 5, fig. 11, 12, 13.

This species is found at Wilmington, Illinois, and at Nye (Iron Ridge) Wisconsin, in the horizon of the top of the Maquoketa series, and is therefore either contemporaneous or a close successor to *O. meeki*, *O. multisecta* and *O. ignota*.

Orthis tersa has thickened valves as compared to other species, and the hinge is short, being only one-half the shell width. The ventral is strongly convex in front of the beak with an increased median convexity which soon flattens and is replaced by a broad median sinus. The dorsal valve is convex and has a narrow median depression that disappears at the margin of some mature shells. The anterior margin is therefore straightened or inflected, and this same with the gradual sloping of the margin from the cardinal angles gives a triangular tendency to the transversely oval outline. The beak on the ventral valve is strongly curved, that on the dorsal is also curved although it is short, and hence the beaks are directly opposed and not far apart. The cardinal areas are small since the hinge is short. The foramen, too, is small, but the teeth and sockets, the cardinal process and the crura are large, while the septum tapers forward. The muscle scars are nearly intermediate to those of *O. ignota* and *O. multisecta*, but the ventral scars diverge more than in either of them.

The outer surfaces at the beaks have been eroded before fossilization and probably during life so that even the initial points of the cardinal process and the crura are bared. Partial removal of the outer shell is not peculiar, but the excessive wear in this case led to inquiry whether the characters of *O. tersa* were not due to erosion of the cardinal angles and beaks of the shell under adverse surroundings, during growth. But other shells in the same strata are not perceptibly injured, and the characters in *O. tersa* are so uniform that the heavy articulating processes and the thickened shell seem to be more like inherited adaptations than acquired ones, whatever their origin.

This and the three preceding species may have been derived from a common parent species. They have in common the single dorsal and paired ventral median plications, and the surface ornamentation so well known in *Orthis multisecta* Meek. The last named character they have in common with *O. rogata* Sardeson, and *O. corpulenta* Sardeson. From *O. rogata* they may have inherited the same and thence also derived their plication.

ORTHIS CORPULENTA Sardeson.

Pl. IV. fig. 11 to 19.

Orthis corpulenta Sardeson (1892) Bull. Minnesota Academy Nat. Sci. vol. III, p. 330, pl. 5, fig. 8, 9, 10.

Orthis (*Dalmanella*) *testudinaria* var *meeki* Winchell and Schuchert (1893), Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. III, p. 445, pl. 23, fig. 25–29. (non S. A. Miller).

Orthis (*Dalmanella*) *meeki* Hall (1893). Palæontology N. York. vol. 8, pt. 1, pl. 5, C. fig. 3.

The types of the species are from the Leptæna bed (13) but it is equally abundant in the Triplecia bed (10). The shells are nearly circular in outline, their width exceeding their length always in young specimens but rarely in old ones. The ventral valve is strongly convex, the dorsal moderately so, but their convexity is often irregularly increased in later growth, and the strongly marked median ridge of the ventral and the corresponding depression of the dorsal valves of early growth broaden and flatten. The ventral valve has the beak sharp and curved well down to the mesial plane, over the equilaterally triangular foramen, which same is nearly blocked by the protruding cardinal process. The septum of the dorsal valve is like that of *O. rogata* except that it has an elevation between the anterior adductor scars. The anterior pair of adductor scars are much larger than the posterior ones, and all are often surrounded by thickened lines and vascular furrows on the shell which much modifies their appearance.

The plication is essentially like that of *Orthis rogata* Sar., with the difference, however, that more plications end on the cardinal margins, and that hence the two posterior fascicles are quite reduced to single primary plications, not noticeable longer on mature shells. The surface ornamentation is like on *O. multisecta* Meek. The earliest specimens of *O. corpulenta* are from the base of the Triplecia bed (10), and the manner of plication, increased convexity, heavy concentric growth interruption lines, and small size, prove them to be dwarfed, like the dwarfed ones of *Orthis rogata* Sardeson, which they in all respects parallel. Alternating median offset plications, and nearly paired median plication are not rare. Nearly all shells have been crushed, apparently by the trilobites, which accounts for the small size of some of them.

Large and normal looking specimens are rare at the base, but common at the top of the Triplecia bed. Dwarfed ones are not known among those from the Leptæna bed (13).

Compared to *O. rogata*, even the dwarfed ones of *O. corpulenta* are larger, the cardinal process is more perpendicular and longer; the muscle scars on the dorsal valve are more elongated, and the plication is coarser, i. e., a specimen of *O. corpulenta* has 60 plications at least while an *O. rogata* of the same size would have 100 developed.

The geologic relation of *O. rogata* and *O. corpulenta* would permit them to be considered as phylogenetically one species, but such a connection has not been traced. The change in the *O. rogata* from the Stictopora bed (no. 4) to the Lingulelasma bed (8), and that in *O. corpulenta* from the Triplecia bed (10) to the Leptæna bed (13), is in each case less than the supposed change from the one to the other, the greatest change being necessarily, therefore, referred to the shortest interval. Among a few specimens seen of *Orthis testudinaria* auct., from Trenton Falls, New York, one kind is, especially in coarseness of plication, more like *Orthis corpulenta* than like *O. rogata*, and the same is probably contemporaneous with the latter, and is the predecessor of the former. The two species vary in nearly like directions, but whether the greater tendency to develop dwarfish characters in the plication, as observed in the larger and later of the two, is inherited from dwarfed specimens of the earlier one, or are independently developed is not known. In the former case it could be that *Orthis corpulenta* Sardeson, had had the same ancestral origin as *O. multisecta* Meek, that in this the acquired dwarfish characters had developed farther, in the other less, and are seen to revert. Under the other theory, the two species are considered as contemporaneous, though closely related, as their surface ornamentation indicates.

ORTHIS EMACERATA Hall.

Pl. v, fig. 14 to 18, 28.

Orthis emacerata Hall, (1860). Thirteenth Rep. N. York State Cabinet Nat. Hist., p. 121; Fifteenth Rep., ibid, pl. 2, fig. 1, 2, 3.

Orthis emacerata Meek, (1874). Palæontology of Ohio, vol. I, p. 109, pl. 8, fig. 1*d* (not *a*, *b*, *c*, and 2).

Orthis macrior Sardeson, (1892). Bull. Minnesota Acad. Nat. Sci. vol. III, p. 330, pl. 5, fig. 5, 6, 7.

Orthis (*Dalmanella*) *emacerata* (1892). Palæontology of N. York, vol. VIII, pt. 1, pl. 5, C, fig, 1, 2.

Orthis (*Dalmanella*) *testudinaria* var. *emacerata* Winchell and Schuchert, (1893). Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. III, p. 445, pl. 33, fig. 23, 24.

The types of the species are from near the middle of the Cincinnati shales (Hudson), at Cincinnati, Ohio, and specimens, together with *O. multisecta* Meek, and *O. meeki* S. A. Miller, were collected there. Others, not different so far as seen, were found at the horizon of *Trinucleus concentricus* Eaton, in strata outcropping below high water mark of the Ohio river at Covington, Kentucky. In Minnesota the species is found in beds No. 12 and 13 of the Maquoketa series. Those referred to in the original description of *O. emacerata* Hall, as found in Illinois and Iowa, are of a different species that is found with *Tellinomya fecunda* Hall, in bed No. 11.

Orthis emacerata Hall* (*O. macrior* Sardeson) are semicircular shells, broadest near the hinge line, and with the margin rounded off narrowly at the ends of the hinge. Their breadth is one-fourth or less greater than their length. The ventral valve is convex, the dorsal one nearly plane, but the convexity is often irregularly increased in both valves of senile individuals, and those marked by many concentric lines. Near the beak of the ventral valve the single median plication is prominent and thence the median fold that expands towards the anterior margin, coincides with the median fascicle of plications. On the dorsal valve a corresponding depression obtains, which is, however, in some, relatively deeper than the opposite fold, so that the anterior margin is straightened. The ventral valve has the beak short, acute and slightly curved, the area about twice as high as that of the dorsal valve, and divided by equilaterally triangular foramen. The cardinal process was a little small and was tripartate, but in poor preservation it is cleft, the middle portion being wanting. The dorsal median septum and the crura are both light in accord with the thinness of the valves, but the dorsal muscle scars are deeply marked. The anterior pair of them are the larger. On the ventral valve the muscle scar area is well defined,—narrowest on thickened shells, when also the vascular sinuses and ovarian spaces are unusually well outlined.

The plication of *Orthis emacerata* Hall, resembles that of large, and hence, flat specimens of *O. rogata* Sardeson. The plications are often graded in size, the first formed then being largest. The surface is without the minute transverse marking that is seen on *O. multisecta* Meek, et al., in all my specimens, but few specimens of *O. rogata* Sardeson, and *O. corpulenta* Sardeson, have it well preserved, the same being easily defaced.

The Cincinnati specimens average larger than those from Minnesota (beds 12, 13), but at Nye, Wisconsin (bed 14), are yet smaller and narrower ones that may be a distinct variety.

Certainly the similarity between *O. emacerata* Hall, and large, and hence flat specimens of *O. rogata* Sardeson, is very great, and one can not doubt that the same is indicative of a close relationship between them. The geologic data would permit of the theory that the latter is the immediate parent species, *O. emacerata* having descended from well favored, like *O. multisecta* from dwarfed individuals of *O. rogata*. The theory might be given consideration were we able to explain the want of minuter surface ornamentation on *O. emacerata*, and were it not that the Trenton of Trenton Falls, New York, yields this type of *O. testudinaria*. The relationship may be concluded to have been geolog ically more remote, and possibly *O. emacerata* is more nearly the parent type.

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*Specimens from the original lot have been obtained for examination through kindness of Prof. R. P. Whitfield, curator of the Geological Department of the American Museum of Natural History, New York city.

ORTHIS PORRECTA n. sp.

Pl. v, fig. 19 to 24.

This *Orthis* is found in the Triplecia bed (10) near Granger, and near Wykoff, Minnesota, associated with *O. corpulenta* Sardeson. Specimens are not numerous, and perfect ones are few. When crushed flat they might be mistaken for *O. corpulenta* in the same condition, or more easily for *O. emacerata* Hall. The last named has not been found in the Triplecia bed, although it must have existed at that period. The "*Orthis testudinaria*," associated with *Tellinomya fecunda* Hall, at Scales Mound, Illinois, and Dubuque, Iowa, are casts, sometimes with shells, which seem to have been fossils transported and deposited as such in the lower strata of the Maquoketa formation. And although most of these *Orthis* belong to the species here described, their occurrence and association with other species in that bed may not indicate that this species lived at that time.

Shells of *Orthis porrecta* n. sp. are about one-fourth, or less, broader than long, the lateral and anterior margins are neatly rounded, and the greatest breadth is about midway forward, or posterior to that. Young specimens are more nearly semi-circular, and old ones circular. The ventral valve is moderately convex and has the beak short, and but little curved, although high so that the greatest convexity of the shell is near it. The dorsal valve, which is equally convex, is deepest centrally. A narrow, shallow median depression on the dorsal valve extends to the anterior margin, and the ventral valve has a corresponding, low median ridge. The area of the ventral valve is about twice as high as that of the dorsal and is divided by the foramen, which is a little narrower than high. The cardinal process, crura and muscle scars on the dorsal valve are all small, and the muscular area of the ventral valve is also not large. The outer surface of the shells has angular, smooth plications that branch much the same as in *O. emacerata* Hall. Concentric lines are few.

From *O. emacerata* Hall, this species can be distinguished by the greater convexity of the dorsal valve, by the circular outline and shorter hinge, by the smoother, but more angular plications, higher cardinal area, and narrower foramen, and by smaller muscle scars.

ORTHIS FUTILIS n. sp.

Pl. v, fig. 25, 26, 27.

In the Triplecia bed (10) at Granger and also near Wykoff and Spring Valley, Minnesota, occurr rarely specimens of an *Orthis* that might, from general characters, be taken for small *O. emacerata* Hall. Similar ones occur in the Wykoff bed (13 and 14) near Spring Valley, and are there associated with *O. emacerata* Hall, some of which they closely resemble. Neither are there very abundant, so that the general relation of the shells is drawn from the characters of a few individuals.

O. futilis n. sp., are small, thin shells, finely plicated, so that while they are much smaller than *O. emacerata* H., they still show an advanced plication and general outline such as seen only in the most mature specimens of that species. The breadth of the shells is about one-fourth greater than the length. The hinge is a little shorter than the whole width of the shell, and the cardinal angles are rounded. The ventral valve has the beak but little curved, and projecting over the cardinal area but little. Its convexity is small, and the median elevation, which is sometimes strong, produces a depression on either side of it. The dorsal valve has a median depression, with convex areas on either side.

In these characters great similarity to *O. emacerata* is shown. The internal characters, seen only in two immature specimens, show also close relation to *O. emacerata*, to which this one might be referred as a variety, if their relation as such could be traced.

GENERAL DISCUSSION.

Of the above described *Orthis*, one only is from the Galena series; the others are found in the Maquoketa series or its equivalent, the Cincinnati series of Indiana and Ohio. The Trenton species, *O. rogata* Sardeson, is the geologic predecessor of them all in the area wherein they are found, and may be the one from which some of them were derived. Morphologically the large individuals of *O. rogata* Sar. are the ones that most resemble *O. emacerata* Hall, by which *O. porrecta* n. sp. and *O. futilis* n. sp. are approached in nearly direct lines. *O. rogata* Sardeson approaches *O. corpulenta* Sar. in many characters and particularly in the extent and direction of variations, but the latter is very much the larger, while resembling most the dwarfish specimens of the former. Dwarfed specimens of *O. rogata* Sar. show characters not seen in large ones, but which are normal in its successor *O. multisecta* Meek and this species has the same characters advanced as compared to the dwarfed specimens of *O. rogata*, but less advanced than the same in *O. tersa* Sar. *O. meeki* S. A. Miller and *O. ignota* n. sp. are in other directions advanced from the development as seen in *O. multisecta* Meek. A few specimens from the typical Trenton of New York, which have been examined, are of two kinds, and are easily referable to *Orthis emacerata* Hall and *O. corpulenta* Sardeson, respectively, as their Trenton representatives. The two Trenton species are practically, if not exactly, contemporaneous with the one Galena species. The three of the Trenton period represent those of the Hudson period, so far as I now know, as follows: *O. emacerata* var., in the Trenton is followed by the typical *O. emacerata* Hall, *O. porrecta* n. sp., and *O. futilis* n. sp., in the Maquoketa (Hudson) and Cincinnati (Hudson) series. Likewise *O. corpulenta* Sardeson is found in both the Trenton and the Maquoketa. *Orthis rogata* Sardeson, is the probable representative of *O. multisecta* Meek, and allied forms. The transitions have not been traced from one species to another, however, in any case, although one finds *O. rogata*, *O. multisecta* and *O. corpulenta* very similar to each other.

I do not find the anticipated evidence of evolutionary development from one species to another, except in the way of morphologic likeness. The geologic evidence serves more to prevent than to aid in forming a phylogenetic connection between the species, since, when we have arranged the supposed phylogenetic lines, the geologic evidence proves, nevertheless, that our specimens represent contemporaneous species, not successive ones. Either each species has migrated to the region where the shells are found, having been evolved in some other place or places in the Ordovician or in the Cambrian sea; or, the change in form between one species and another has taken place in a few individuals, under special conditions, and is therefore obscure. Again, when we try to call them local varieties, of one species, we are compelled, by the evidence, to acknowledge that the "mere varieties" are distributed very widely, and are not local; that, too, they existed apart and together under very like, as well as quite unlike conditions. In short, it is not proved by specimens in my collection that the above described *Orthis*, whether called species or varieties, are not distinct. I have, therefore, made a more minute morphological analysis and comparison than brachiopodists usually do. If the evolutionary development in Brachiopoda is to be traced, it will be necessary to make clearly distinctions in form as minute, and even much minuter, than these.

None of the above described species are like, or similar to, Dalman's* figures, and to the best of my knowledge, there is ample room for preference of Meek's view† that our forms may none of them be identical with those described as *Orthis testudinaria* by Dalman, or those identified with that species in England. The necessary material for a comparison of

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*See Pal. N. York, vol. VIII, pt. 2, tab. II, fig 4 *a-c*.

†Pal. Ohio, vol. I, p. 111.

them is not at hand. There are certainly other "*O. testudinaria*" than the above described, even in America.

Owing to the close morphological likeness between the species which have been above described, it seemed necessary to assume that they must be phylologically near one another, and I have tried to explain how, among other characters, the differences in plication of the valves evolved. Some of the species have a single median plication on the ventral valve, like nearly all *Orthis*, others, on the contrary, have the single median plication on the dorsal, and a double median plication of the ventral valve. Probably the latter has been derived from the former, but the difference, however derived, is seen not only in the mature shells, but likewise in the smallest of plicated ones. The primary cause of the plication of *Orthis* I do not know, unless it is in the modification of the mesial circumference relative to the convexity of the valves.

Beecher and Clarke have studied, with special attention, the development and characters of *Orthis elegantula* Dal., and *O. hybrida* Sow., in their well known work on the Brachiopoda of the Waldron shales,—Niagara, Silurian. These two species are so near " *O. testudinaria*" that with the usual latitude, they might even be included it it. The results of their work must, therefore, not be passed without special comment. They give us the result of their study of an abundant collection of *Orthis* from Waldron, that the tests of *O. hybrida* and *O. elegantula* are not distinguishable in extremely early stages of growth,—2 or 2.5^{mm} length—and "that the diagnostic characters of species of this genus may not be assumed until the earlier stages of the shell have passed."* From a few specimens at hand, it appears to me that the plication† at least should serve as a distinctive mark on shells of 0.5^{mm} if it is possible to distinguish in them the ventral valve of *O. hybrida* Sow., from the dorsal of *O. elegantula* Dal. The small—2^{mm}—shells of the latter are like those of *O. rogata* and *O. corpulenta* of the same size, in having a single median plication on the ventral valve. Those of *O. hybrida* Sow., as appears on little larger shells, have, from the first, a double median plication, i. e., a median furrow on the ventral and the single median plication is on the dorsal valve like *O. multisecta* Meek. *Orthis hybrida* Sow., belongs, one might say, to the *O. multisecta* type, even though its dorsal valve is more convex, and its hinge shorter even than *O. tersa* Sar. Regarding *O. elegantula* Dal., its internal characters are very like those of *O. corpulenta*, etc., from which it differs in relative convexity of the valves, and in length, breadth, etc. *O. elegantula* Dal., if derived from any Ordovician "*O. testudinaria*," has newly acquired a greater proportionate length of test, and the plication shows a corresponding modification. Small ventral valves have a single median plication which does not remain, however, in the median plane, but one of the first offset plications becomes median; this, in turn, branches, and so on, in such a manner as to form a conspicuous branching right and left from the median line or plane. Several plications on this one are added to the single median plication of *O. corpulenta*. Branching on the rest of the valve is, as a rule, from the side of the older plication in direction away from the median line, or posteriorly. The external and internal characters in this species are such as might be considered to be those of *O. corpulenta* Sar., modified, by extension of the anterior shell margin. *Orthis hybrida* Sow., being of the *O. multisecta* type, and *O. elegantula* Dal., of nearly the *O. corpulenta* type, it would further seem inconsistant to adopt James Hall's view* and place *O. hybrida* in a separate genus or sub-genus from "*O. testudinaria*" and *O. elegantula*, and particularly so if one is to consider *O. meeki* at the same time, simply as a "coarse-ribbed variety" of *O. testudinaria*. *O. vanuxemi* Hall, represented by a few specimens at hand, agrees with *O. hybrida* in having a single median plication on the dorsal instead of ventral valve, and the other species of that type, bear to *O. vanuxemi* a very close resemblance.

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*See Memoirs of the New York State Museum, vol. I, no. 1, p. 13, 14 and 17.

†Those from Waldron and some from England are just alike.

The relation between *Orthis multisecta* Meek, *Orthis emacerata* Hall and the other above described *O. testudinaria* auct., may be made somewhat clearer by comparison to one or two other groups of that genus. Firstly, *Orthis* (*Platystrophia*) *biforata* Schl. appears in the Fucoid bed (5), and persists in succeeding beds 6, 7, 8, 9, 10, and again in 12, 13, and 14 in the Galena and Maquoketa series. This is the same species that is found in the Trenton of New York. In the Galena and Maquoketa series it is the only *Platystrophia* wherever yet found. But in New York and Ohio it belongs to the Trenton group. Other species or varieties, *O. lynx* Eichw. *O. acutilirata* Conrad, *O. laticostata* Meek, et al. take its place in the Hudson shales. All the *Platystrophia* are contemporaneous species, or practically so in the Hudson epoch, and are distinct. The Trenton representative is the predecessor, too, of all the Hudson species, and may be the parent species of all. It is a synthetic type as compared to them. Again, in *O. bellarugosa* Conrad of the Galena series, and *O. insculpta* Hall of the Maquoketa, we have two unique nearly like forms with mere varietal differences perhaps. In them as in those of *Platystrophia* and '*Orthis testudinaria*,' a close phylogenetic relationship is apparent, while so far as represented by specimens of fossils in collection the species all, or varieties, whichever they be called, are distinct.

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*Pal. N. York, vol. VIII, pt. 1, p.

DESCRIPTION OF PLATES.

Plate IV.

Orthis rogata Sardeson fig. 1 to 10.

FIG. 1. Ventral view of an average sized shell, from the Fucoid bed.

FIG. 2. Ventral view of small shell, base of Orthisina bed, (× 10).

FIG. 3. Analysis of ventral plication of specimen from the Fucoid bed.

FIG. 4. Exact median, longitudinal section. Fucoid bed.

FIG. 5. Same as fig. 4 with the parts of the shell analyzed.

FIG. 6. Interior outline of a dorsal valve, to show the muscle scars, septum and crura. Orthisina bed.

FIG. 7. Interior of dorsal valve. Fucoid bed.

FIG. 8. Cardinal area, crura and cardinal process, same as fig. 6. (× 2.)

FIG. 9. Cast taken from interior of a ventral valve. Fucoid bed.

FIG. 10. Natural cast of another specimen. Fucoid bed.

Numbers 1, 2, 3, 4, 5, 7, are from Ellsworth, Wisconsin; 2, 9, 10, are from Saint Paul; and 6, 8, are from Berne P. O., Minnesota.

Orthis corpulenta Sardeson, fig. 11 to 19.

FIG. 11. Dorsal view of a large specimen. Leptæna bed.

FIG. 12. Lateral profile. Leptæna bed.

FIG. 13. Ventral view small, young specimen. Leptæna bed.

FIG. 14. Analysis of ventral plication of an average specimen, from the Leptæna bed.

FIG. 15. Interior of dorsal valve, in outline. Triplecia bed.

FIG. 16. Same as last, shaded.

FIG. 17. Longitudinal, median, section, with the parts of the valves analyzed. Leptæna bed. (N. B. Part of the line bounding the pedicle callist lost in the development of the plate.)

FIG. 18. Natural cast of the interior of a small ventral valve. Leptæna bed.

FIG. 19. Cast taken from the interior of a large ventral valve, Leptæna bed.

Numbers 15, 16 are from Granger, the others from Spring Valley, Minnesota.

Orthis multisecta Meek, figs. 20 to 23.

FIG. 20. Dorsal view of a specimen, Cincinnati shales, Cincinnati, O.

FIG. 21. Analyzed ventral plication of same.

FIG. 22. Lateral profile of same.

FIG. 23. Median longitudinal section.

Orthis meeki S. A. Miller, figs. 24 to 29.

FIG. 24. Ventral view of a specimen found with *O. multisecta* Meek.

FIG. 25. Lateral profile of average specimen, Madison, Indiana.

FIG. 26. Longitudinal median section of one like the last.

FIG. 27. Analysis of ventral plication of another specimen.

FIG. 28. Cast taken from interior of ventral valve.

FIG. 29. Interior of dorsal valve.

Number 24 is from Cincinnati, O., the others are from Madison, Indiana.

PLATE V.

Orthis ignota, n. sp., figs. 1 to 7.

FIG. 1. Ventral view of young specimen.

FIG. 2. Ventral view of average size.

FIG. 3. Analysis of ventral plication of the last.

FIG. 4. Lateral profile of same specimen.

FIG. 5. A longitudinal median section, analyzed.

FIG. 6. Natural cast of ventral valve, interior.

FIG. 7. Dorsal valve, interior.

All are from the Leptæna bed, Spring Valley, Minnesota.

Orthis tersa Sardeson, figs. 8 to 13.

FIG. 8. Dorsal view of typical specimen.

FIG. 9. Analysis of ventral plication of the same.

FIG. 10. Lateral profile.

FIG. 11. Longitudinal section.

FIG. 12. Cast taken of interior of ventral valve, partly restored.

FIG. 13. Interior of dorsal valve, partly restored.

All are from the topmost Hudson strata at Wilmington, Illinois.

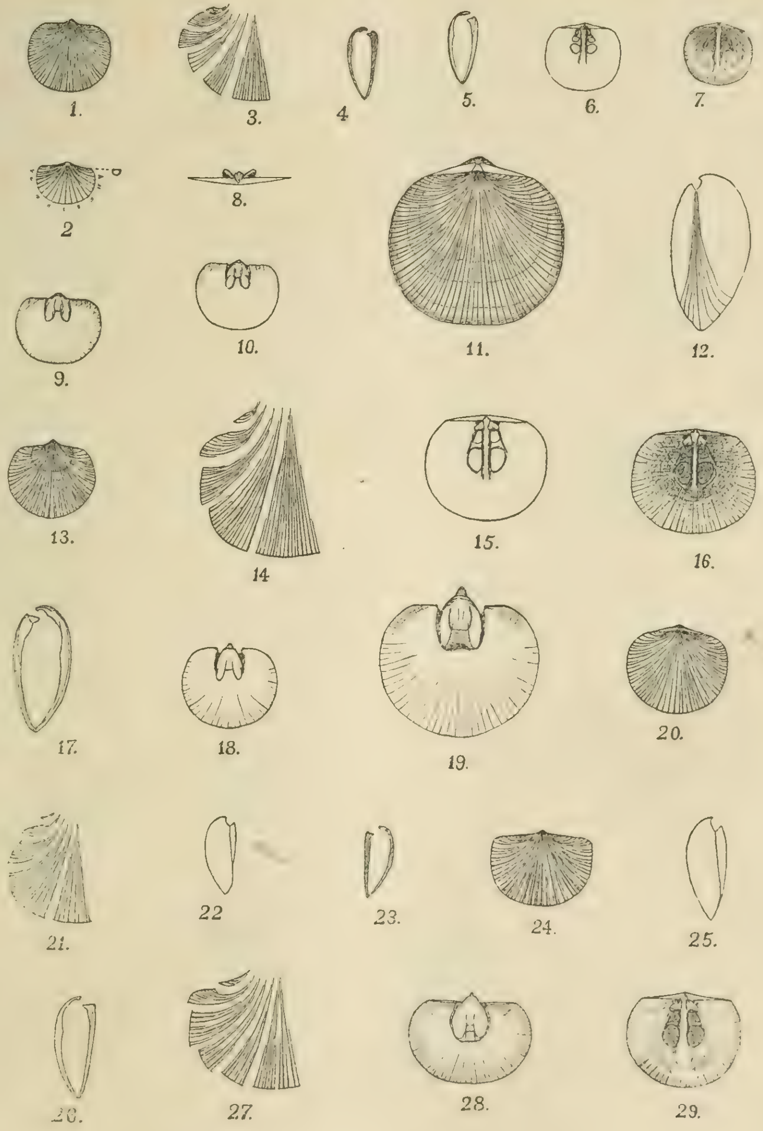
Orthis emacerata Hall, figs. 14-18, 28.

FIG. 14. Dorsal view of an average specimen, Leptæna bed.

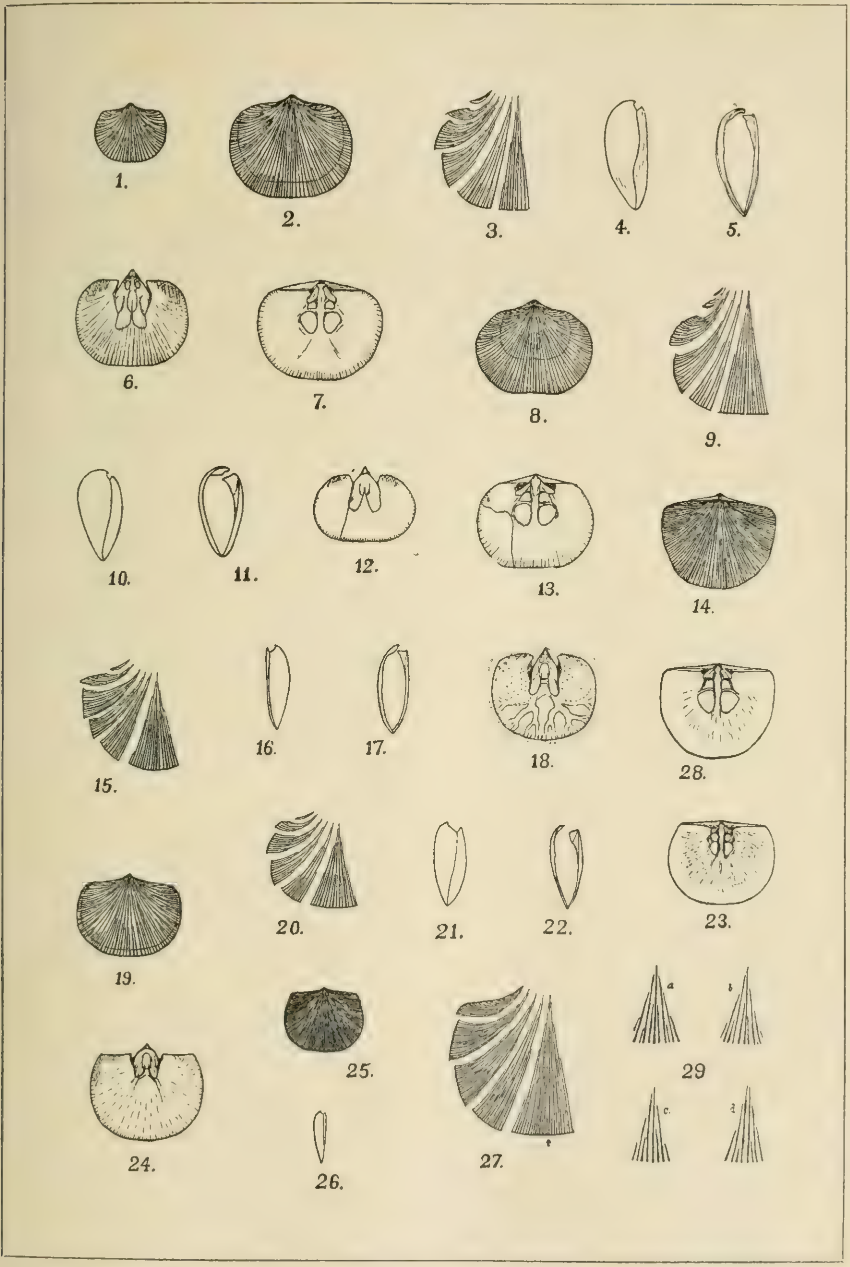
FIG. 15. Ventral plication of the same specimen.

FIG. 16. Lateral profile of an average specimen.

FIG. 17. Median, longitudinal section, Leptæna bed.



ORTHIS TESTUDINARIA.



ORTHIS TESTUDINARIA.

FIG. 18. Natural cast, from the Orthoceras bed. Ventral valve with the exterior profile restored in broken line.

FIG. 28. Cast taken from a natural cast of a dorsal valve, Orthoceras bed.

Numbers 14 to 17 are from near Spring Valley, numbers 18 and 28 from near Granger, Minnesota.

Orthis porrecta n. sp., figs. 19 to 24.

FIG. 19. Ventral view of specimen with shell, Triplecia bed.

FIG. 20. Ventral plication of last analyzed.

FIG. 21. Lateral profile.

FIG. 22. Longitudinal median section.

FIG. 23. Interior of dorsal valve.

FIG. 24. Cast taken from interior of a ventral valve.

All are from near Wykoff, Minnesota.

Orthis futilis n. sp., fig 25 to 27.

FIG. 25. Ventral view of full sized specimen, Triplecia bed.

FIG. 26. Profile of the same, partly reconstructed.

FIG. 27. Ventral plication of the same × 2.

From near Granger, Minnesota.

FIG. 29. Diagram showing the gradual change in the median fascicle of plications, from single ventral median plication with paired offsets (*a*), to alternating offsets (*b*), to nearly paired (*c*), and paired (*d*) median and first offset plications.

RULES AND MISRULES IN STRATIGRAPHIC CLASSIFICATION.

By JULES MARCOU, Cambridge, Mass.

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THE SWANTON AND QUEBEC-CITY FORMATION.

At Swanton, (Vermont) and at Quebec city, we have about five thousand feet of strata, almost all slates, with a few lenticular masses of limestone, in concordance of stratification with the Phillipsburgh and Pointe-Lévis group, and which contain a fauna of graptolites, with now and then, in sporadic geographic distribution, a few fossil forms which develop as important faunas in the Chazy and Trenton formations. Those sporadic fossils recall the "colonies" of Barrande, and by their rarity and stratigraphic positions among an enormous mass of slates, do not allow to call the very limited beds of limestone in which they are found true Chazy, or true Black River and Trenton formations.

A memoir entitled: "The value of the term 'Hudson River' in geologic nomenclature," (*Bull. Geol. Soc. America*, vol. I, pp. 335-356), aims at classifying those five thousand feet of strata as belonging to the Lorraine shales; that is to say, to place them at the top of the second fauna, or Champlain system.

The author, Mr. C. D. Walcott, after saying that "the strata of the Hudson group cannot be delimited clearly, as the base and summit of the series are not shown," does not hesitate to refer the Swanton and Quebec-City group to the formation of Lorraine of Sandy creek, Jefferson county, although he admits that no true Lorraine fossils have ever been found there; the nearest place containing Lorraine fossils being close by Albany, west of the Hudson river. As to the complete absence of the great graptolitic fauna in the interior of the state of New York, Mr. Walcott says "it was prevented by some barrier." What barrier he does not explain; making use of it, not only for the unlucky graptolites, but also to explain the absence of the true Lorraine fauna from the valley of the Hudson, using imaginary barriers to prevent extension of faunas, without regard to stratigraphy and simply because barriers of some sort are wanted to give an explanation of a classification made absolutely against all rules; just as at some other places invisible faults are called to aid for the same purpose. Certainly such principles of classification were never thought of by Alexander Brongniart, nor William Smith, even less by Ebenezer Emmons and Barrande. Lately, the geological survey of Canada has given a table of formations for the border country of the United States, comprising Phillipsburgh—the typical locality—and being a continuation of the stratigraphy of the vicinity of Swanton, which disagrees almost *in toto* with the classification previously given of the Hudson River group by the late palæontologist, now director of the U. S. Geological Survey. In it the Quebec-City formation, or Swanton slates, is placed below the great Trenton formation, instead of being above. And another great difference also exists as regards the Calciferous, which is not considered as the equivalent of the Phillipsburgh series. Here is the classification given by Mr. Henry M. Ami, the palæontologist of the Canadian Survey (*Annual Report, Geol. Surv. of Canada*, vol. VII, new series, p. 113, April, 1896, Ottawa).

Lorraine.
Utica.
Trenton, including Black River.
Quebec-City formation.
Phillipsburgh formation.
Chazy formation.
Calciferous formation,
Potsdam sandstone.

How the Geological Survey of Canada contrives to place between the Trenton, including the Black River, and the Chazy formation—at only a few miles distance from Chazy village—the five thousand feet of the Quebec-City and Swanton formation, and the eighteen hundred feet of the Phillipsburgh series, is not explained and so far is a complete mystery, against all rules of classification. However, we must be thankful to Mr. Ami that he did not correlate the Quebec-City formation as the equivalent of the Trenton, or as belonging to the Utica or Lorraine, as it has been placed for so many years in the previous publications of the Canadian Survey. It is a progress due to the exertion of Mr. Ami, however faulty his classification is even now, which shows how difficult it is to come to a rational and exact classification, when misled by erroneous interpretation of palæontology and stratigraphy.

THE STOCKBRIDGE LIMESTONE AT RUTLAND.

Now we come to another irregular and erroneous classification made against all rules; it is the Stockbridge limestone described in a paper entitled, "On the Lower Cambrian age of the Stockbridge Limestone" (*Bull. Geol. Soc. America*, vol. II, pp. 331-338, Rochester, March, 1891).

The age of the strata at Rutland (Vermont) is made out by a wrong interpretation and use of palæontology, without the support of any description and figures of species and with the smallest amount of fossil remains imaginable. *First*, with only a few specimens—all in fragments—belonging to the genera *Kutorgina*, *Salterella* and *Lingula*, the author, Mr. J.

E. Wolff, refers the Rutland marble quarry, on which the village is built, to the "Elliptocephalus (Olenellus) zone," which he calls Lower Cambrian (Lower Taconic), instead of the upper part of the Middle Taconic (Middle Cambrian). In the absence of trilobites, or any other fossil characteristic and common at Georgia, the correlation of the Rutland marble with the Georgia formation is an hypothesis without a palæontological basis. It belongs to the Taconic system, as Dr. Emmons says, and very likely to the lower part of the Phillipsburgh and Pointe Lévis formation, that is to say, to the base of the Upper Taconic, just above and in contact with the Georgia formation,

Second, the marble quarries of Centre Rutland and West Rutland are referred to the Trenton-Chazy-Calciferous formation, a rather curious compound, which it is impossible to justify stratigraphically, or lithologically, or even less palæontologically, for Mr. Wolff quotes only as fossil remains found there, a few crinoid stems.

The author gives a sketch geological diagram of the vicinity of Rutland, showing plainly the peculiar stratigraphy of large lenticular masses of limestone marble, inclosed in slates; just as at Shoreham and at Phillipsburgh, a stratigraphic feature characteristic of the Taconic system, which has even not attracted the attention of Mr. Wolff, who does not notice it.

THE GREEN MOUNTAINS IN MASSACHUSETTS.

After many years of opposition to the Taconic system at its typical locality, the vicinity of Williamstown, Massachusetts, without a single particle of proof, a very elaborate memoir has been published at last, in 1895; it is entitled "Geology of the Green Mountains in Massachusetts," by Raphael Pumpelly, J. E. Wolff and T. Nelson Dale, in *Monographs of the U. S. Geol. Surv.*, vol. XXIII, Washington, 1894. In the preface, at p. xiii, Mr. Pumpelly says: "It has been our intention to keep wholly clear of the Taconic controversy and to confine our efforts to accurate study and interpretation of structure." Unhappily all his efforts break down from the first page, and throughout the memoir he has spoken constantly of Lower Silurian and Lower Cambrian, referring strata to those two systems of rocks without proper proofs of any sort and against all rules of stratigraphic classification. If the authors had been contented to give the classification of strata, as they make it out by stratigraphy, it would have given to their work a character of impartiality, at the same time a true value, which no controversy would have been able to make use of, except to quote the facts well observed and clearly described.

Here is the series and its classification as given on the *Map of Greylock and Hoosac Mountains, to illustrate the Geological structure of the Green Mountains*, 1891, Plate I:

SILURIAN	Greylock schist. Bellowspipe limestone. Berkshire schist. Stockbridge limestone.
CAMBRIAN	Vermont formation.

The Stockbridge limestone is divided in two, the lower part being classified as Lower Cambrian (Lower Taconic) and the upper part as Lower Silurian (Champlain or true Cambrian of Sedgwick, or Ordovician), a most extraordinary compound of a group of strata, absolutely incorrect and materially impossible. But more, the geological map is obscured by a double classification of two formations, one called "Rowe schist," referred to the Silurian, and the other called "Hoosac schist," referred to the Silur-Cambrian. As no explanation of that double classification exists on the map, the reader in order to understand it must look at p. 13, a figure called "Correlated columns of the Hoosac and Greylock rocks." Here it is in the form of a table:

Greylock Mt.	*Hoosac Mt.*
Greylock schist	Rowe schist.
Bellowspipe limestone Berkshire schist Stockbridge limestone	Hoosac schist.

Greylock Mt. and Hoosac Mt. are separated only by a narrow valley. It is to be expected that the authors would see such lithologic difference between the strata forming opposite mountains that they would have come to the conclusion I have constantly advocated since 1862, that there are at mount Greylock lenticular masses or islets of magnesian limestone (Stockbridge and Bellowspipe limestones) inclosed in the slates (Berkshire and Greylock schists).

We are constantly confronted in that memoir with the expression "Lower Silurian fossils," but not a single one is quoted, even by generic name; and as to Cambrian (Taconic) fossils, there is only the indication that Mr. Walcott has found at Clarksburg mountain, on the prolongation of Greylock mount, "numerous casts of *Olenellus* (*Elliptocephalus*), showing the lower part of the quartzite to be of Lower Cambrian (Lower Taconic) age." No description, no figure of that trilobite is given, so we do not know if it is the species of Georgia, although it seems to point out that it is, with the wrong determination of Lower Cambrian—as at Manuel brook (Newfoundland)—instead of the upper part of the Middle Cambrian (Middle Taconic). To add, if possible, confusion to the already sufficient amount of unproved correlation, the authors hint at p. 29 that the Rowe schist may represent "Hudson River group!" or "perhaps Medina time"!!

We read at pp. 127-128 of the report on mount Greylock, by Mr. T. Nelson Dale, the following correlation, which is anything but the "intention to keep wholly clear of the Taconic controversy," expressed in the preface of the memoir.

Greylock schist. Thickness 1,500 to 2,200 feet. Walcott's Hudson River (Lower Silurian).

Bellowspipe limestone. Thickness 600 to 700 feet. Walcott's Hudson River (Lower Silurian).

Berkshire schist. Thickness 1,000 to 2,000 feet. Walcott's Hudson River (Lower Silurian).

Stockbridge limestone. Thickness 1,200 to 1,400 feet. Walcott's "Olenellus" (Lower Cambrian).

The whole is in concordance of stratification, a stratigraphic anomaly rather difficult to explain; but no attempt is made in that direction.

We have in the whole memoir the most flagrant disregard of all the rules in stratigraphic classification and correlation as they were established by the founders of stratigraphical and historical geology.

THE NEW RED OR DYAS AND TRIAS.

Dr. Ebenezer Emmons was the first observer who divided the great series of the New Red sandstone, in the eastern or Atlantic states, into Permian (Dyas) and Trias in his "Geological Report of the Midland Counties of North Carolina," Raleigh, 1856. Following closely all the rules of stratigraphic classification, he referred the Chatham series of North Carolina to the Permian (Dyas), and the Deep River series with the Coal series of Chatfield county in Virginia, as well as the Red sandstone of Anson and Orange counties in North Carolina to the Trias, the whole having a thickness of more than 5,000 feet. It was an excellent first start, to arrive at a rational classification of the numerous strata of the New Red sandstone which extends from the two Carolinas to the Connecticut valley. Instead of following the researches so well begun in North Carolina, the geologists who studied the New Red in Virginia, Maryland, Pennsylvania, New Jersey, Connecticut and Massachusetts, seem to have had in view to use the fossil remains found there to diminish as much as possible the importance of the classification of Dr. Emmons, reducing it to the smallest and youngest part of the New Red classification of Europe, and seeing in the American strata only the equivalent of the Rhetic formation. Even at first an attempt was made to refer the whole series of the eastern United States to the Lower Oolite of the Jura of Yorkshire (England).

Happily the Geological Survey of Pennsylvania, thanks to the carefully executed researches of the geologist, Mr. Benjamin Smith Lyman,* in the two counties of Bucks and Montgomery, has found out, first, that the series, instead of having a thickness of only 1,500 feet, was about 27,000 feet thick, and second, that the palæontologic age of that series has never been satisfactorily determined in Pennsylvania, New Jersey and the Connecticut valley.

Mr. Lyman has divided the whole series in Montgomery county in the following manner:

Doubtful age	Pottstown shales	10,700 feet.
	Perkasie shales	2,000 “
	Lansdale shales	4,700 “
Trias—Gwynedd shales		3,500 “
Dyas—Norristown shales		6,100 “
		27,000 feet.

The age of the upper part, that is to say, the great divisions of Pottstown, Perkasie and Lansdale, is rather doubtful, on account of the rarity of fossils. It may be in the greater

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*See “Some New Red Horizons” (*Proc. Amer. Phil. Soc.*, vol. xxxiii, 1894); a most interesting paper, not only on the question regarding the New Red, but also as regards “geological methods as distinguished from purely palæontological ones.” See also “Report of the New Red of Bucks and Montgomery counties” (*Pennsylvania State Geological Summary, Final Report*, vol. iii, Part II, 1895).

part, perhaps even in totality Triassic, or the upper portion may belong to the Jura. The Gwynedd shales represent the whole Trias of Europe. To correlate it with only the small Rhetic group is an error, due to a too narrow interpretation of fossil plants and their true stratigraphical positions in the beds of the Gwynedd shales, where they are scattered all over the 3,500 feet. As to the 6,100 feet of Norristown shales, they represent the Chatham series of North Carolina, and can be safely correlated with the Dyas (Permian) of Europe.

West of the Mississippi river the New Red sandstone was not discovered until 1853, when one of the parties of the Pacific Railroad exploration in following the 35th degree of latitude brought out the fact of the existence in the Indian territory, Texas, New Mexico and Arizona of a series of 6,000 feet, divided into 5,000 feet of Trias and 1,000 feet of Dyas (Permian). In 1863 an exploration of Nebraska proved there the existence of the Dyas, south of the Platte river, more specially at Nebraska city. Those two discoveries, made by the present writer, evoked one of those too numerous passionate critiques from the two recognized leaders of American geology, Messrs. James Hall and James D. Dana, who, with the help of Messrs. Newberry, Meek, Blake and others, made the most stupendous and unreasonable opposition. As a result arrived at by their observations and researches in the field and in the laboratories, they came to the conclusion that the series of beds, instead of representing the Dyas and Trias, belonged to the Lower Cretaceous (Dakota formation, the American equivalent of the Turonian of France) and to the Carboniferous. Such a correlation would have been only comical if it had not stopped for a quarter of a century, and more, the progress of American geology, and had not brought before the International Congress of Geologists at Berlin, in 1885, the emphatic and most positive declaration from Messrs. James Hall and Newberry that the Permian (Dyas) did not exist anywhere in North America. A single quotation of one typical locality will suffice as an example. The section at Nebraska city, with descriptions of fossils and plates, was published in 1864-'66 and '67 at Paris and Dresden (Saxony), and all European geologists, more specially the German and Russian—where are the typical localities of the Dyas—recognized the exactness of the synchronism. But in America special researches were made under the U. S. Geological Survey by order of Dr. F. V. Hayden; and his associate, Mr. Meek, made a "Report on the Palæontology of Eastern Nebraska," published in the *Final Report of the United States Geological Survey of Nebraska*, Washington, 1872, in which he opposed the classification of the series of strata at the Nebraska city landing made by the present writer and professor Hans Bruno Geinitz, and after long discussions, filling fifty pages, Meek came to the conclusion that "these rocks belong to the Coal Measures." It took twenty-two years to show the error, and it is only in 1894 that at last Mr. Charles S. Prosser, in his paper, "Kansas River section of the Permo-Carboniferous and Permian Rocks of Kansas" (*Bull. Geol. Soc. Amer.* vol. VI, pp. 29-54), confirms my determination of the age of the Nebraska series from the mouth of the Platte river to the Nebraska city landing, saying at p. 50. that professor Tschernyshew of St. Petersburg and of the Geological Survey of Russia, after a visit to Nebraska assured him that both faunal and lithologic characters can be duplicated in the Permian of Russia. It is one of those too numerous misrules of stratigraphic classification and correlation, entirely unjustifiable and unnecessary, and made against plain facts well pointed out stratigraphically, palæontologically and lithologically, but disregarded by the leaders of American geology, making wrong use of rules and principles so firmly established by Cuvier, Alex. Brongniart and William Smith.

JURA.

During the exploration for a Pacific railroad route by the 35th degree of latitude north, in 1853, the present writer, after recording the existence of the New Red sandstone, on a vast surface between Delaware mount (Indian Territory) and the Llano Estacado, met at the Tucumcari area, in New Mexico, a formation of white sandstone strata, in concordance of stratification upon the New Red, containing no fossils. But above the mass of white sandstone—more than one hundred feet thick—he met at the base of a formation of blue clay, a bed entirely filled up with a *Gryphæa* of the group of *Gryphæa dilatata* of the Oxford clay of England and France, which he called *Gryphæa tucumcarii*. Naturally he correlated the white sandstone and the blue clay of the Tucumcari area with the Jurassic system or period. Many years after—1889—a thorough exploration of the Tucumcari region by Mr. A. Hyatt disclosed in the limestone strata just above the blue clay containing the *Gryphæa tucumcarii* an upper Jurassic fauna, of at least twenty species, which are referred to in a paper "The Jura in Texas" (*Proceed. Boston Nat. Hist. Soc.* vol. 27, p. 149-158). It is unnecessary to repeat here what was said in that paper, which gives all the reasons for correlating the series of strata of the Tucumcari area and those of the Kent section (western Texas), as well as those of the Bosque, Glen Rose or Trinity of eastern Texas and the Trinity division of Pike county, Arkansas, with the Jura of Europe. Only I shall say that the extraordinary, erroneous correlations of those strata, first with Dakota formation and afterward with the Neocomian, have made confusion in the historic geology of North America and are still preventing the Texas Survey and the U. S. Geological Survey from using a correct classification of one of the most important systems of the Mesozoic.

The Laramee Formation and the Puerco Beds.

One of the most uncalled for and wrong classifications is the age assigned to a great mass of strata of fresh water, with now and then brackish water deposits existing in the plains and Rocky mountain region, more specially round fort Laramée* (wrongly spelled Laramie). Dr. Hayden first discovered that formation in 1859 and properly referred it to the Tertiary. Thickness about 4,000 feet. It is composed mainly of *molasses* or sandstones, not unlike the Molasses of Switzerland. with shales, pure sands, and sometimes coal strata, with a few and rare calcareous beds. It rests in retrogressive stratification on the marine strata of the Upper Cretaceous, called Fox Hills group and Fort Pierre group or Montana formation, containing a fauna the exact equivalent of the Upper White Chalk of England and France.

The geographical distribution of the Laramée is very different from the distribution of the Montana formation,and shows a great change in the distribution of the land and water, just like the one so well known in the classic basin of Paris and

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*Laramée is the name of the first French voyageur who explored and trapped on La Platte river, at the beginning of this century. Laramée, Laflamme, Lafontaine are common names among French Canadians.

London, where the Tertiary strata lie in retrogressive stratification on the White Chalk.

The palæontologic characteristic of the Laramée formation is an absence of marine animals, unfossiliferous strata in comparatively large districts, and the appearance, now and then, of fossil remains of brackish water mollusca forms, terrestrial vertebrates and leaves of plants, as well as fossil woods. The invertebrate fauna is similar and correlated to a fauna found in the Lower Eocene of the Adriatic province of Austria. The vertebrate fauna is identical, for the mammalia, with the Cernaysian fauna of the Lower Eocene of Ay and Cernay, near Reims, in the celebrated Champagne district of the Tertiary Paris basin. Finally, the flora contains so many new types entirely Tertiary that to call it a Cretaceous flora would be an entirely unnecessary confusion, created against all sound principles of palæontology.

The correlation of the faunas of the Laramée formation with the faunas of the Lower Eocene of Europe is most perfect, and requires no more discussion after the excellent and most important memoirs of M. Lemoine (*Bull. Soc. géol. France*, 3d series, vol. xx and xxi, Paris). Professors Zittel of Munich and Gaudry of Paris, after a study and comparison, are convinced and do not place any longer the Laramée formation in the Cretaceous, but in the Tertiary. As to the Puercos formation, considered by professor Edw. D. Cope as older than the Laramée formation, it is only a subdivision of the Laramée just below the group of strata in which was found the celebrated mammalian fauna wrongly called by Messrs. Marsh and Cope "a mammalian Cretaceous fauna."

So now there is not a single doubt left about the age of the Laramée formation, and it is to be hoped that the United States Geological Survey and the U. S. National Museum will conform their classification to the rules used everywhere in stratigraphical geology on that simple question of correlation and classification of a mass of strata of fresh and brackish water origin placed between the Chalk and the Oligocene in America, just as it is placed in Europe.

THE CHICO-TEJON FORMATION.

The last great confusion, created in stratigraphic classification in North America by an erroneous use of palæontology, is the reference of the Chico-Tejon formation of California to the Cretaceous system, instead of putting it at its right place, the Tertiary Eocene.

Dr. A. Randall first discovered at Chico creek, Butte county, California, in 1855, a series of strata containing a rather rich fauna, composed mainly of gasteropods and acephales, essentially characteristic of the Tertiary Eocene. Dr. Trask, the first geologist appointed by the State of California, on the recommendation of Dr. Randall, made a careful study of the locality, in following the cliffs of the Chico creek, which are rather difficult to explore on account of a flow of lava volcanic rocks, which covers the Tertiary strata. Among the numerous Tertiary fossils two cephalopods were found, the *Baculites chicoensis* and *Ammonites chicoensis*, two degenerate forms, according to the best authority on cephalopods, professor A. Hyatt. Both Drs. Randall and Trask had no hesitation in referring the strata of Chico creek, according to the principles for correlation established by Alexandre Brongniart, to the Tertiary; and Dr. Trask published those two cephalopods in "Description of a new species of *Ammonites* and of *Baculites* from the Tertiary rocks of Chico creek" (*Proceed. California Acad. Nat. Soc.*, vol. I, p. 85, San Francisco). In classifying the Chico series as Eocene Tertiary the authors followed the rules for establishing synchronism and equivalency at great distance from the typical region of the recognized great systems or geological epochs. M. A. Rémond de Corbineau, an excellent expert for Cretaceous and Tertiary rocks, after an exploration of Monte Diablo referred also, in a *Report of Monte Diablo district*, the same series of rocks to the Eocene Tertiary or Chico creek group of Drs. Randall and Trask.

But the correlation was not accepted by the group of the leaders of American geology, who declared that it was impossible that *Ammonites* and *Baculites* existed in California during the Eocene time, when such invertebrate marine animals did not exist in Europe, or even on the Atlantic borders of North America. Against all knowledge of geographic distribution of marine animals of the present time some palæontologists have established the mathematical rule, that forms of animals have disappeared all over the surface of the terrestrial globe, at the same moment; a most erroneous principle, contrary to the teaching of Brongniart: and with no other base than a supposition and a hypothesis, contrary to well authenticated facts of the present fauna—simply a "speculative palæontology" according to R. Owen's right expression.

The opposition to the observations and Tertiary references of Drs. Randall, Trask and Mr. Rémond de Corbineau took the form of an opposition absolute and uncompromising. The only reason given by the opponents being that it is impossible that *Baculites* and *Ammonites* could exist in the California region of the earth when such cephalopods did not exist any longer in Europe; they have no right to be there, and consequently when you find them you can say, with an absolute confidence, that the strata in which they lie belong to the Cretaceous system and are not Tertiary. With such misrules the publications of Messrs. Newberry, Gabb, and afterward of Dr. C. A. White, have created confusion, which has prevented the progress of geology on the whole Pacific coast, and notwithstanding the opposition made by Mr. T. A. Conrad and myself, we are still confronted by an erroneous classification. However, the mathematical rulers have abated some of their opposition, accepting at last that the Tejon group is not Cretaceous, but Tertiary, and even admitting that the Martinez group also is not Cretaceous, retaining only the Chico group in the Cretaceous system.

Lately Mr. J. S. Diller in a paper, "Cretaceous and early Tertiary of Northern California and Oregon" (*Bull. Geol. Soc. America*, vol. 4, pp. 205-224, Rochester, 1893), has not only detached the Chico from the Tejon and accepted the Tejon as Tertiary, but he tries to create a "Shasta-Chico series," the Shasta being formed of two great divisions of true Cretaceous strata called "Horsetown and Knoxville beds." He insists on the passage and connection between the upper part of the Shasta and the lower part of the Chico. *First*, Mr. Diller does not prove that the series called by him Chico beds is really the original group of Chico creek of Butte county. And *second*, he calls Chico a series called by others "Wallala beds," from a series of strata exposed at Wallala, Mendocino county, California, and which are not proved to be truly identical with the Chico group as originally created by Randall and Trask. The California Geological Survey, directed from 1860 to 1874 by J. D. Whitney, extended greatly the Chico group at the same time that it created the Tejon group and the Martinez group, and referred the whole three groups to the Cretaceous system, with the forced result of the suppression of the Tertiary Eocene in California (*Geol. Surv. California*, vol. II, preface by J. D. Whitney, 1869). The present writer, in a second visit to California, during 1875, more than twenty years after a first exploration in connection with the Pacific railroad exploration by the 35th degree of latitude, took special care to investigate the typical localities of Fort Tejon and Monte Diablo and was enabled to give, for the first time, the geological section in the vicinity of Fort Tejon (Report on the Geology of a portion of Southern California in *Annual Report Chief of Engineers to the Secretary of War*, pp. 158-172, Washington, 1876), showing beyond any possible doubt that the Tejon group was Tertiary; that the Martinez group was an artificial division without any value, and that the fauna collected by Drs. Randall and Trask was truly Eocene Tertiary, while the fauna of the Tejon indicated an upper Eocene or Oligocene age.

The Wallala beds seem Cretaceous, and it is possible that some confusion has been created by referring them to strata regarded as Chico beds by some errors of correlation. An exact equivalency must be established by rigorous comparison of the fauna of the Wallala beds and the fauna of the Chico creek before drawing the conclusions arrived at by Mr. Diller.

But whatever may be the result of detailed observations in northern California, we possess now enough facts from the researches made at Chico creek, Monte Diablo, the Coast ranges, south of San Francisco as far as Fort Tejon, to allow us to say that great confusion in classification and correlation, in an important part of the stratigraphy of California, is due to a wrong use of palæontology, united with a total disregard of stratigraphical principles, and lithology. It is no wonder that the geologists who started from California, with the erroneous classification adopted by the survey of that state, wanted to place the Laramée formation in the Cretaceous, as an extension and as an off-shoot of the Chico-Tejon formation. The one was a corollary of the other.

From Chico creek, Monte Diablo, to Fort Tejon, the Chico-Tejon formation is never seen lying on the Cretaceous system of Shasta; at some places, as at Chico creek and Fort Tejon, the two great groups do not exist together, showing that a break occurred at the end of the Chico creek formation, while at other places, like Monte Diablo and the Coast range south of San Francisco, the two great groups appear to lie in concordance of stratification. Following the rules of classification and correlation, we have in California a great system of strata, belonging to the Tertiary; a break divides it from the true Cretaceous of Horsetown and Knoxville: and another break of smaller value makes two subdivisions of the formation. The lower one, or Chico creek group, is the equivalent of the Lower Eocene of Europe, and the upper one, or Tejon group, is the equivalent of the Upper Eocene, called Oligocene. Over it we have, in southern California, at San Fernando, Los Angeles, etc., the Miocene, or Molasses of Switzerland, and the Pliocene; so we have in California a complete, and most important and well developed series of the Tertiary epoch, just as in Europe.

QUATERNARY OR PLEISTOCENE.

It is hardly necessary to refer to what has been called "Tertiary auriferous gravels," by the director of the Geological Survey of California, Mr. J. D. Whitney, who went so far as to classify all the Quaternary and the glacial deposits of the Sierra Nevada in the Miocene and Pliocene. Never before nor since, in any part of the world, have the Post-Pliocene or Pleistocene strata given rise to such an erroneous classification, based on a wrong interpretation and use of palæontology. It is absolutely incomprehensible and inexcusable.

CONCLUSIONS.

Each time that the rules and true principles of the stratigraphic classifications are put aside, progress is rendered extremely difficult, and even entirely stopped for a long period of years. Generally the observations carefully made by recognized practical geologists are accepted; but when passed over, as if they did not exist, confusion reigns supreme, and lasts as long as the accepted leaders are there to impose their wrong views and their glaring errors. It would appear easy for leaders to change their opinion, when shown their fallacies; but then they would not be leaders any longer, and it is what they will never submit to.

Alexandre Brongniart and William Smith had no idea that the great principles of strata identified by organic remains, would be used in such a way as to pave the road to the success of error and mistake, instead of showing how to work in order to get at truth.

POST SCRIPTUM. NEW GEOLOGICAL MAP OF NEW YORK.—The geological map of the state of New York, so long expected and referred to in THE AMERICAN GEOLOGIST, vol. XIV, p. 259, has been at last presented to the public, the 24th of August, 1896, at the meeting of the American Association for the Advancement of Science, at Buffalo. The title is: "Preliminary Geologic Map of New York, exhibiting the structure of the state, so far as known. Prepared under the direction of James Hall, state geologist, by W J McGee. Published by authority of the Legislature of the state of New York. Printed by the United States Geological Survey, J. W. Powell, director. Scale 1: 316,800, 1894." It is in six large sheets, of which two are simply map outlines, without any color or any geological indications. On the four other sheets, one only is complete, it is the one representing the western part of the state, called generally and known as the "Fourth Geological District." The other three sheets, comprising the southern, eastern and northern parts of the state, are incomplete; large areas in several counties, like, Dutchess, Columbia, Washington, Warren, Essex, Clifton, Franklin, Lawrence, Jefferson, and Levis, as well as the whole of Long Island, are left blank.

No explanation has been published yet, or even given orally when the map was presented to the American Association for the Advancement of Science, and we are obliged to read it without any help as regards classification and nomenclature; that is to say, without the chronological dates on which it has been constructed, except the rather obscure "legend," printed on the sheet containing New York city and its environs. The constructor of the map, Mr. McGee, has only let us know, without explanation, that "unexpected difficulties have been encountered."

In order to compare the three geological maps of New York, issued in 1842, 1844 (although dated 1844, that agricultural and geological map was kept away from the public until 1877, and even until 1885), and 1894 (practically issued in 1896). I give below the "legends:"

1842.

Alluvial (no color, but signs)

S.	Tertiary { Sand plains. Clay.
R.	Trap rock.
Q.	New red sandstone.
P.	Catskill Mt. rock.
O.	Portage and Chemung.
N.	Hamilton.
M.	Helderberg series.
L.	Onondaga Salt group.
K.	Niagara.
I.	Clinton.
H.	Medina sandstone.
G.	Gray sandstone and Shawangunk grit.
F.	Hudson River group or Lorraine shales.
E.	Utica slate.
D.	Black River and Birdseye limestone.
C.	Calciferous sand rock.
B.	Potsdam sandstone.
A.	Primary system.

1844.

Agricultural and Geological Map of the State of New York. Almost the same coloration as the map of 1842, only a large belt of drab is introduced to show the Taconic system.

1894.

Sedimentary rocks.

Kr.	Cretaceous.	
Ju.	Jura-Trias.	
C.	Carboniferous.	
Dcl.	Catskill.	Devonian.
Dch.	Chemung.	
Do.	Oneonta.	
Dpt.	Portage.	
Dhm.	Hamilton.	
Don.	Onondaga.	
Dor.	Oriskany.	
Sh.	Helderberg.	Silurian.
Ssl.	Salina.	
Sng.	Niagara.	
Scl.	Clinton.	
Sm.	Medina and Oneida.	
Shr.	Hudson and Utica.	
Shrm.	Metamorphic Hudson.	
Str.	Trenton.	
Strm.	Metamorphic Trenton and Calciferous.	
Scf.	Calciferous.	
Cp.	Potsdam.	Cambrian
Cg.	Georgia.	

Younger igneous rocks.

Ancient crystalline rocks, divided in six groups.

The western, or fourth district, as well as the central portion, or third district, are the easy part of the work; the formations and beds following one another with the regularity of tiles upon a roof, or steps on a staircase, without any difficulty of succession, of disturbance or faulting. For that part of the map, all that was required, to make it more exact, was to mark the limits of each group or formation with more accuracy, and to add some details in the classification of some of the great and important groups like the Chemung and Portage, where a new division has been introduced between them, under the name of "Oneota." Besides it was important to establish the correlations with the great stratigraphic systems of Europe, a work so well done by De Verneuil in 1846, and which wanted to be transferred on the official geological map of the state.

The state geologist, Mr. James Hall, has followed closely the researches of Vanuxem, Conrad and De Verneuil, improving by well observed details the stratigraphy of all the country between Schenectady, Schoharie, Buffalo, and the boundary line of the state of Pennsylvania, and his map of 1894 is a great improvement on the geology and geography of the third and fourth districts. So now, thanks to the Geological Survey of New York, and its director, Mr. James Hall, we possess for that important portion of the state a correct and excellent geological map.

But the other portions, especially the eastern, or first geological district, are still far from satisfactory, on the map of 1894. Dr. Ebenezer Emmons, on his geological map of 1844, with the approbation of Vanuxem, introduced a new great system of deposits of about 25.000 feet of strata, lying east of the Hudson river and of lake Champlain, which he proved by stratigraphy, palæontology and lithology to be older than the Lower Silurian or Champlain system, and which he called most appropriately the Taconic system. It was a stroke of genius on the part of Dr. Emmons, who, before any other geologist or any other country, found in America the true base of the sedimentary strata, the primordial fauna, and consequently the first and most important great geological period in the history of the earth.

Dr. Emmons did not color any of the divisions made by him in the Taconic, and he was satisfied to place the whole of it under a single color. The map of 1894 follows Emmons in using also a single color for the strata of the Taconic system, only it replaces the name Taconic by a name of a village of the state of Vermont, "Georgia"; and almost two-thirds of the strata of the Taconic are cut off and placed farther up in the scale of formations, as we have seen and explained in the first part of this memoir. The Georgia group of Mr. Hall occupies, on his map, first, narrow lines in the southern part, east of the Hudson river, then going northward the lines become patches, and finally when the southern boundary of Rensselaer county is reached the Georgia formation takes the form of broad bands, extending through the state of Vermont. If we compare those Georgian outcrops with the Taconic of the map of Emmons of 1844, we see that the main part of the original Taconic between Williamstown (Massachusetts), and Albany and Troy (New York), is inclosed in the Georgian. The only difference consists in the broadness of the great band of Primordial, the map of 1894 reducing the dimension of the band on both sides (east and west) so as to frame and involve almost totally the Taconic within strata which are called Silurian.

Here now comes the delicate and not satisfactory point, for whatever may be the opinions or personal inclinations, it is difficult to accept as identical, formations differing in every way, stratigraphic, lithologic and palæontologic, and with thickness absolutely most disproportionate with the standard and typical formations close by—being separated by distances less than the range of a cannon-ball shot. In order to avoid this difficulty Mr. Hall has created two new divisions in the Lower Silurian or Champlain system under the names of "Metamorphic Trenton and Calciferous" and "Metamorphic Hudson River formation." The state geologist, instead of preserving distinct the two divisions of the Hudson or Lorraine and Utica, as they are on the maps of 1842 and 1844, has united them in a single division called "Hudson River and Utica," with the omission of the word "Lorraine."

In the legend the position occupied by the two new "metamorphic" divisions is misleading, for the metamorphic Trenton and Calciferous is placed between the normal Calciferous and the normal Trenton, and the metamorphic Hudson is placed between the normal Trenton and the normal Hudson, which seems to imply that the metamorphic divisions preceded the normal divisions with which they are identified, being, according to the legend, older than their typical and normal forms; which would be just the contrary, for if they are truly the metamorphic of the divisions they are claimed for, they ought to be placed above those divisions and not below, for the metamorphism as the word implies came always after the deposition of the regular strata and consequently succeeded in the chronology of geologic history.

On the map of Mr. Hall those two divisions cover vast surfaces in the most eastern parts of New York, entering the state of Massachusetts and extending northward through the state of Vermont.

In order not to embarrass the reader with too many technical and geographical details, we can say, that in the main, the new geological map of New York concedes to the Taconic of Dr. Emmons about one-third of the surface occupied by that stratigraphic system. The two other thirds are regarded by Mr. Hall and his assistants as belonging to the Silurian, calling, when it suits them, the strata "metamorphic" Calciferous, Trenton, Hudson, and even Oneida (the last under the name of Rensselaer grits). Why the name "Metamorphic" is used, there is no explanation, and if we consult the works published by members of the United States Geological Survey on the Rensselaer grits plateau, the Green mountains of Massachusetts, etc., we do not see any trace of metamorphism among all the strata there; and, as farther north, in Vermont and in Canada, no metamorphism exists also, we have no explanation whatever of what is meant by "metamorphic Calciferous, Trenton, Utica, and Hudson." But supposing that the strata under discussion are metamorphic, that does not imply the apparition of completely different faunas, of thickness ten and even twenty times greater, of slates instead of limestones. Metamorphism, no more than invisible faults or invisible barriers, can not be of any use to explain the existence of five thousand and more feet of strata at Quebec city, Pointe Lévis, Phillipsburgh, Highgate, Swanton, Shoreham, Troy, Stockbridge, etc., etc., with their numerous fossils, almost totally different,—with only an exception of ten or a dozen forms—from those found in the typical and classic Calciferous, Trenton, Utica and Lorraine (Hudson). A misuse of palæontology against the rules advocated by Alexandre Brongniart, Edward Forbes, Thomas Huxley, and others, cannot change the age of strata. The Upper, the Middle, and Lower Taconic, with a thickness of 25,000 or 30,000 feet of strata, not metamorphic, containing at different levels, several faunas most characteristic and quite rich in number and forms, exist in eastern North America; and the sooner the different organizations of official surveys accept the plain facts, as they are in the field, the better for the practical geology of the western hemisphere.

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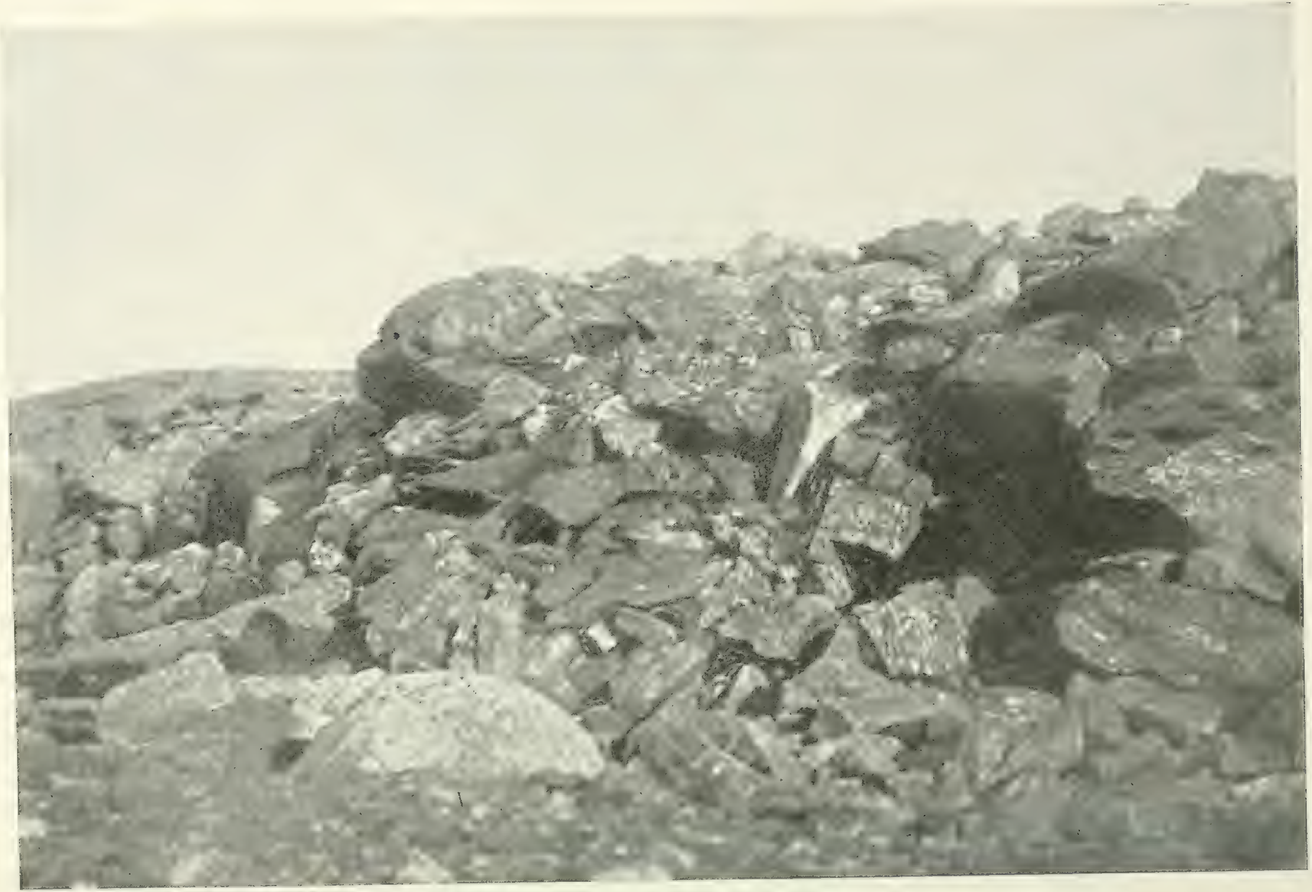

POST-GLACIAL WEATHERING—TOP OF DEVIL'S THUMB.

Altitude 2650 feet. Transported pebbles found here. Distance from present ice-margin, about three miles.

Now, a few words, as brief as possible, on the *status* of the Geological Survey of New York, and the United States Geological Survey. After more than fifty years of opposition to the acceptance of the Taconic system, the adversaries of that system have conceded that one-third of the portion of the map colored by Dr. Emmons as Taconic, is truly of that age, or, according to their nomenclature, is Georgian and Cambrian. It is certainly a progress. Only, at that rate, it will take one hundred years more for the adversaries of the Taconic system before they will accept the whole system. And we shall have the unique case in historic geology of a great period, first blotted out from existence, and then, little by little, creeping along at the most painful and incredibly slow pace, until after a lapse of a century and a half, we shall find our knowledge of the primordial system of eastern New York and western Massachusetts just at the same point where its discoverer, Dr. Ebenezer Emmons, placed it in 1844. What a slow progress! entirely due to the opponents and persistent adversaries of the Taconic system.

Cambridge, Mass., December, 1896.

RAPIDITY OF WEATHERING AND STREAM EROSION IN THE ARCTIC LATITUDES.

By R. S. Tarr, Ithaca, N. Y.

[Plate VI.]

Weathering. Evidence that Baffin land and parts of Greenland have been recently glaciated is found on every hand. In the case of that part of Greenland especially studied by the Cornell party last summer,* it was found that the ice is still withdrawing from the land, and that some sections have been uncovered so recently that vegetation has not yet begun to cover the rock and the morainal soil. Very nearly the same remark holds for one of the nunataks located about seven miles from the land. On this, although many forms of plants have found a home, the heavy-seeded varieties have not yet begun to grow, except in a very few widely scattered colonies. Notwithstanding the recency of this ice covering, the weathering during the brief post-glacial time has been sufficient to produce marked changes upon the surface. To me the evidence of the amount and rapidity of weathering and erosion in the Arctic came as such a surprise that I wish to call especial attention to it.

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*In connection with the expedition organized by Lieut. R. E. Peary.

One might expect that nearly the entire action of weathering in the higher latitudes would be that of mechanical destruction, but such is not the case. Possibly because crevices are opened by the frost, the rocks readily and rapidly decay as a result of the chemical changes of the minerals. This disintegration of the rock has been slight wherever it has been protected by even a thin soil or vegetable covering. It is upon the exposed rock face, nearly bare of vegetation, and open to all the changes of weather that the rapid disintegration is noticed. Hence these chemical changes are not sensibly dependent upon the presence of vegetable acids. It is true that on nearly all exposed rocks there are many lichens, but these are hardly competent to furnish much vegetable material to the percolating water. The oxygen and carbon dioxide of the air, working with the water, are the chief elements of change. As a result of these chemical changes the rock is often discolored by iron salts, and considerably altered near the surface; but nowhere has it been in operation long enough to have caused distinct soil of decayed rock particles.

While notwithstanding the general absence of vegetation, and the low temperatures of the water, chemical disintegration is actually in progress, and apparently not slowly operating, the chief weathering that is seen is that of mechanical kind. One very important agent of this change is the lichen. Few parts of the world will yield a more abundant lichen flora than this northern country, north of the timber belt. The ledges, boulders and even the tiny pebbles, are almost everywhere lichen-covered, and as they grow these must be performing a mechanical work of rock disintegration of high importance.

It is of course in the decided changes of temperature, and the extremes of cold in winter, that we are to find the most energetic agents of weathering in these high latitudes. The expansion and contraction of minerals with the changes of the temperature, and the effect of frost in the crevices, are active agents in breaking up the rocks. With the extremes of cold during the winter the minerals must become brittle, and this result may also aid in the breaking up of the rocks; for when a rock is extremely brittle the strains caused by contraction, resulting from continued cold, will then be much better able to break off fragments than at other times. Whatever the exact cause, flakes, bits and even blocks of large size are riven from the ledges and cliffs. Even on horizontal surfaces one often sees remarkable instances of the spreading of rocks, evidently as the result of frost action, on the joint and bedding planes. Great blocks have moved horizontally for distances of several inches, or even in some cases a foot or two; and upon gentle inclines the down hill sliding of disturbed blocks is evidently rapidly in progress.

Upon steeper slopes the blocks fall as soon as they are loosened from their beds. In both Greenland and Baffin land, although recently ice covered, and certainly scoured sufficiently to remove the loose materials, the most characteristic surface feature, besides that of the bare rock ledges, is the talus accumulation at the base of the cliffs and on the sides of hills. One can rarely travel in any direction without very soon having his path leading him over a talus of frost-riven boulders; and so rugged is the surface as a result of this that the average rate of travel over the land in the part of Greenland where our party worked was not over one or one and a half miles an hour. In these talus deposits the surface of the blocks is usually rusted by iron salts derived from the chemical changes which are in progress, and they are generally covered with lichens; but every now and then single blocks, or areas of blocks, of fresh gneiss mark the recent falls from the cliffs above. Upon gentle slopes talus blocks are present and evidently moving down hill. Everywhere frost and cold are at work on a grand scale.

The talus slopes are often combined with a ruggedness of topography quite out of harmony with the outline of a glaciated country, as we commonly understand it. Some of this ruggedness is an inheritance from pre-glacial times. In fact the great cliffs, hill slopes and valleys, and even many of the moderate features, are thus inherited. In many places the ice action has not been sufficient to greatly smooth the surface. However, much of the irregularity is distinctly of post-glacial origin.

Erosion. With rapid weathering there is accompanying rapid erosion. This is partly due to the fact that the hills of Baffin land and Greenland have steep slopes, which have been inherited from pre-glacial times, and partly to the fact that at certain seasons there is a great supply of water for the work of erosion.

I am told by those who have spent years in the Arctic that one can form no conception of the amount of water that is engaged in this work of erosion; but even a summer trip prepares one to partly understand the amount and power of this water. During the summer months many of the streams flow in their rock-encumbered beds, out of sight beneath the boulders. One may climb the mountain side in a stream bed,with the sound of running water in his ears, and not be able to obtain a drop from the stream that is coursing along beneath the boulders. Then the rain comes, and the streams swell, until the water rises above the boulders, overflows the valley and becomes a raging torrent. The surface of all the land becomes wet, even though the rain fall may have been slight.

This marked increase in the amount of water in the stream is due only in part to the increased melting of the snow banks, and only in part to the supply of water obtained from the increased melting of the frost that is in the soil. It is mainly the concentration of the rainfall over the general drainage basin. Very little of the water sinks into the earth, partly because the greater portion of the land surface is bare rock, which readily sheds the rain. and partly because, even where the surface is soil-covered, the soil is already nearly saturated by water furnished from the frost, which even in the late summer exists at the depth of a foot or two below the surface. By this the soil is kept constantly damp and usually even wet, while below the very surface it is frozen into a solid mass, so that there is a barrier to the percolation of water into the ground. Naturally, therefore, since most of the water must flow away into the streams, even a slight rain causes a perceptible swelling of all the rivers and rivulets.

During the winter the surface of all the land, excepting the most precipitous, is snow-covered, and with the appearance of the summer sun this commences to melt and run away in the streams. Snow-born rills and even rivers spring rapidly into existence, and the water cascades down the hills and leaps as waterfalls over the face of the cliffs. Some of the snow, the banks in sheltered spots, lasts through the summer; but by the middle of July nearly all the winter snow has disappeared from southern Baffin land and from that part of Greenland which lies south of Melville bay. For a month or two before this there is exceedingly great activity of water action, and then it is that cliffs are carved and mountain gorges enlarged.

I have never anywhere, not even in the high mountains of the west, seen such evidence of rapid down-cutting and torrential flow as that found on every hand in Greenland. The stream beds are littered with huge boulders tons in weight, and there was one case, in a fjord at the base of the upper Nugasuk peninsula, of a delta made of such boulders, which had not only been dragged down the valley of the torrent, but had been carried out for a hundred yards, over a nearly level stretch, and stranded on the edge of a delta whose area was several acres.

Though similar violence of erosive action is often illustrated in lofty mountains, in this case it was not so much the steep gradient of the stream bed which caused the remarkable transportation, as the enormous quantity of water turned so quickly into the stream. In this region therefore, although active erosion is confined to two or three months of the year, the sum total of work done exceeds that which rivers are usually able to accomplish with a full year for operation; and the work equals, and perhaps exceeds, that done in mountains where, although the slope is greater, the water supply is less favorable to intense action.

Former Rapid Erosion in New York. Even before this evidence of great intensity of erosion in these high latitudes came to my attention, I had thought that our own region of eastern United States furnished evidence of intensity of stream action greatly in excess of that now being accomplished. Now that I have seen the present results of this increased intensity, due to great water supply for short periods, I feel convinced that this evidence has been correctly interpreted.

The gorges of central New York, near lakes Cayuga and Seneca, are in some cases much broader near their mouths than their heads. In some cases, notably in Estey's glen on the eastern side, and Taughannock gorge on the western side of the southern end of lake Cayuga, the present streams are engaged in cutting narrow gorges. Below the falls in these streams the valleys are broad, though still distinctly post-glacial gorges. The valley width is entirely out of proportion to the size of even the broadest torrents that now flow through them. It is as much out of proportion as the late summer stream is to the gorge valley which the spring torrents are now carving in Greenland.

It will not suffice to say that weathering and stream meandering have broadened the gorges in their lower reaches, for the change in width of the gorge is abrupt. Moreover in some of the smaller streams the broad lower gorge is now being littered by talus heaps, upon which trees are growing; and this shows that the water supply of the present is not only unable to cut so large a gorge, but cannot even dispose of the rock load furnished it by weathering. The condition reminds one of the abandoned outflow channel of lake Bonneville, and the shrunken streams of the far west. Once occupied by large streams, they are now becoming littered by the products of weathering from the valley sides.

If this interpretation is correct, and the time near the close of the Glacial period was one of greater water supply to the rivers, as we may well expect that it would have been, it is hazardous to draw conclusions from post-glacial gorges concerning the length of time that has elapsed since the Glacial period. This adds another important element of uncertainty, and in the case of Niagara it may well be sufficient to partly or entirely counteract the less rapid work that some believe was done during the time of diminished water supply. Double the amount of water that flows over Niagara falls, even for a very short time, and the rate of work in gorge formation will certainly become greatly accelerated.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ueber cambrische und silurische Phosphoritführende Gesteine aus Schweden, von Johan Gunuar Andersson (Bull. Geol. Instit. of Upsala, No. 4, vol. II, Part 2, 1895.) Under the above title Herr Andersson gives a very full account of the various deposits of phosphate rock found in Sweden, with the geological age, conditions and mode of occurrence of this substance at the several horizons where it has been found to exist.

The literature of the subject is fully treated, beginning with the discoveries in Dalecarlia and Westgotland in 1870, and continuing with those in Œland, Schoren, Nerike, Angermanland, Norbotten, East Gotland, etc. Various well known Swedish geologists have taken part in, and discussed these discoveries.

The phosphate deposits have been found at several horizons, the oldest being in the Lower Cambrian in several districts, viz.: Gotland, Œland and Gotska Sandön, the next the Middle and Upper Cambrian at Œland, Horn and Dalecarlia. The third horizon is at the base of the Ordovician in Nerike, Wambe, Œland, etc.

From an examination of the phosphate nodules of the base of the Ordovician, which he affirms to constitute a conglomerate, Herr Andersson concludes that this is not an original deposit of phosphatic material, but consists of rolled fragments derived from the Upper Cambrian alum slates beneath. This is shown by the fragments of various species of Cambrian trilobites contained in these phosphate nodules (Petura Sphœrophthalmus, Ctenopyge, etc.)

On the other hand, he considers that the phosphate is indigenous in the Cambrian horizons. The oldest Lower Cambrian phosphate zone, he calls the *Torellella lævigata* (formerly *Hyolites l.*) conglomerate. *Michwitzia* (formerly Obolus) *monilifera* is said to occur with the Torellella and it is shown to lie above Olenellus (now *Holmia*) *kjerulfi.*

The phosphate horizon in the Middle and Upper Cambrian is called the Acrothele granulata conglomerate, and contains a variety of fossils, chiefly those of the "Middle" Cambrian, with one or two from the Lower Cambrian and several from the Upper. It appears therefore, to have accumulated at some localities during much of the Cambrian age.

Among the conclusions which Herr Andersson bases on his study of the Swedish Cambrian bed, are the following: Wherever, in the Swedish Cambrian—Silurian, narrow shore-deposits are met with, we find also numerous occurrences of phosphatic nodules. The Lower Cambrian *Torellella*-bearing conglomerate, the Obolus conglomerate in Dalecarlia and the Island of Œland, together with the Lower Silurian *Strophomena jeutzschi* conglomerate are apparently phosphatic beds of an undoubted littoral nature. Speaking of the glauconite which appears in the *Str. jeutzschi* horizon, the phosphate-bearing shallow-sea layers contain masses of glauconite grains, while the glauconite played a subordinate part in the littoral phosphate bearing deposit. This occurrence of the glauconite in the Swedish Cambro-Silurian layers is in complete accordance with the bathymetric diffusion of sediment rich in glauconite in modern seas. In the littoral and sub-littoral zones (of the sea) glauconite has never been found. Recent sediments rich in glauconite and phosphate of lime have an exact bathymetric equivalent in the above described shallow-water formations rich in glauconite and often phosphate bearing, of the Cambrian and Silurian terrains.

Herr Andersson draws a distinction between the shore deposits poor in glauconite and the shallow sea formation rich in glauconite; both types have a great extension at various horizons, both in the Cambrian and the older Lower Silurian; the younger Lower Silurian is formed of fine sediments, slates and limestones in which glauconite and phosphate of lime play no important part.

The shells of the inarticulate brachiopod, which occur in more or less abundance in the Lower Cambrian sandstones, are looked upon as the source of the phosphate of lime in the nodules found in the older Palæozoic rocks of Sweden. G. F. M.

The distribution of the Cambrian and Lower Silurian formations in Siberia, by Baron Toll (Memoirs of the Russian Imperial Mineralogical Society vol. xxxiii, I, 1895.) It was *Th. Schmidt* who first announced the existence of Cambrian beds in Siberia. This well known scientist in the year 1886 described three species of trilobites [*Agnostus czekanowskii, Liostracus maydelli* and *Anomocare pavlowskii*] which are found in the basin of Olenek in the lower course of Koika and on the Vilni river. We have no later information upon the stratigraphy and distribution of these deposits in Siberia.

Very recently Mr. Baron Toll, who studied the collections of Middendorf Czekanowski and Lopatin, the well known travelers in Siberia, concludes, that the Lower Silurian and Cambrian beds have a very large development in this country.

The author shows that the well known but previously not clearly determined "red rocks" of Lena are to be referred to the Silurian. In Krivolutzki (on the Lena river) occur undoubted Lower Silurian beds containing *Asaphus*, *Phacops*, *Beyrichia*, *Primitia*, etc., and extending westward to the Middle and Lower Toongooska. This horizon consists generally of sandstone, breccia and limestone, and in the upper beds often contains gypsum. The dip of the strata is southwestward.

To the northeast from this place, in the neighborhood of Olekminsk, (on the Lena river), Mr. Czekanowski has found the beds which underlie the "red rocks" of Lena. These beds are represented by reddish brown limestone and contain *Obolella* (sp). and several forms of *Microdiscus*, which manifest the near relationship with the *Microdiscus speciosus* and *M. lobatus* Walc., described as the Lower Cambrian forms of America.

According to Mr. Baron Toll, these Cambrian beds occur over a large area; they stretch to the Tabaginsk station (near Takutsk on the Lena river) and, probably, to the Olenek river, where the stylolite limestone is found, similar to the Cambrian limestone of Lena, but very poor of fossils. In it was found only one pigidium of a trilobite of the genus *Dikelocephalus*.

Perhaps, to this large Cambrian basin can be referred the stylolite limestone with Foraminifera, developed in the Middle Toongooska, and the limestone of Torgoscha, which contains the trilobites, *Proetus slatkowski* and *Cyphaspis sibericus*, as well as the corals that Mr. Toll described as forms of the genus *Archecocyathus*, for the first time found in the Cambrian of Canada and having a large extension in the Cambrian of Europe. Since in the Cambrian of European Russia only littoral deposits occur, the author thinks the most probable explanation of this fact is to suppose that these corals were migrating from the east. A. W. P.

The ancient volcanic rocks of South Mountain, Pennsylvania. FLORENCE BASCOM. Bulletin No. 136, U. S. Geol. Survey, 1896. Octavo, 124 pp., 28 plates of microscopic characters and geological map; 15 cents. This work reviews previous descriptions of the igneous rocks of South mountain by the geologists of Pennsylvania, beginning as early as that of Lewis Evans, in 1755, and ending with the last expressions by Hunt, Frazer and Lesley. By these geologists, without exception, these rocks were regarded as metamorphosed clastics. An exception might be made, as noted by Miss Bascom, of the sketch of J. F. Blendy, 1879, who referred to the greenstones as "amygdaloidal trap," and correlated the formation with the copper-bearing rocks of the lake Superior region. The acid rocks, however, he considered still as "slates."

It was in 1892 that appeared the first paper which advocated the igneous origin of these rocks, the result of field work done by the late Dr. Geo. H. Williams and by Miss Bascom. Since then the same geologists have fully demonstrated, by more detailed examinations, not only the eruptive nature of these rocks, but also their probable extension along the Appalachian mountains, from Vermont to North Carolina.

These volcanics are associated with certain sedimentary strata which, on the basis of some examination, Mr. Walcott has concluded are of pre-Cambrian age. The structural evidence of the prior date of the volcanics is, however, not as convincing as is desirable. Dr. Williams, indeed, was led to express his doubt as to the volcanics being earlier than all of the sedimentary strata. They may be older than the Potsdam sandstone, which is correctly classed, there, as Cambrian, but there is a much older and very important member of the Cambrian which exists below that quartzyte.

The author's description of the three rock types is full and convincing, on all the questions on which she differs from the Pennsylvania geologists.

These three types are:

"1. A siliceous sedimentary rock, represented by a quartzose conglomerate, a sandstone and a quartzyte. This is rarely accompanied by an interbedded argillaceous slate.

"2. An acid volcanic rock which shows all phases of crystallization, from a spherulitic rhyolite to a true quartz-porphyry, is amygdaloidal or compact, is accompanied by pyroclastics and breccias and is sometimes sheared into a perfecty fissile shale or sericite-schist.

"3. A basic, holocrystalline, volcanic rock which is usually amygdaloidal, massive or more frequently schistose, and is also accompanied by pyroclastics and breccias and sheared to a slate."

The various conditions and structures of these rocks are described with clearness and acumen, as might be expected of a young geologist who had received a petrographic training from the lamented Williams.

Nos. 2 and 3 above are the types that carry the crucial characters, and the most of the essay is devoted to the description of their peculiarities. The acid eruptives which are the "primal upper slate" of Rogers, range in color "from a brick red, through pink, purple, blue, gray to ashy-green, light green or buff." They are sometimes porphyritic, spherulitic and eutaxitic. They are occasionally amygdaloidal. They contain flow breccias and tuff breccias.

The basic eruptives are more widely extended than the acid, constituting the rock of many of the valleys, foothills and mountain flanks. Originally massive, they have become schistose or slaty by pressure and shearing. They exhibit a marked and frequent amygdaloidal structure. They also contain bands and beds of volcanic ash in which are also volcanic bombs. In one instance an agglomerate is mentioned, consisting of rounded fragments from an inch to six inches in diameter. These characters are fully identified and described, and there can no longer be any question as to the nature of these "primal slates," whether of the upper or the lower series.

The characters of these rocks, as noted above, as well as their well known content of metallic copper, and their stratigraphic position, afford so perfect a parallel with the Keweenawan of the lake Superior basin that their identity in age with the great copper-bearing formation of lake Superior can hardly be questioned. It is really a surprising commentary on the comparative thoroughness and skill with which the two regions have been examined to note that the true character of these "primal slates" has been detected only within recent years (Dec. 1892), whereas the igneous nature of the lake Superior eruptives has been known since about 1842, an intervening period of fifty years, indicating the backwardness of the geology of the Appalachians.

In conclusion we desire here to commend the suggestions of the author as to the nomenclature suitable for such acid rocks, viz., a devitrified rhyolyte, obsidian or perlite becomes aporhyolite, apobsidian, apoperlite, the prefix *apo* having a significance co-ordinate with *meta* and *epi* in petrographical nomenclature. N. H. W.

The Relation of the Fauna of the Ithaca Group to the Faunas of the Portage and Chemung. By EDWARD M. KINDLE. Bulletin No. 6, vol. II, Bulletins of American Paleontology, Ithaca. N. Y., contains 54 pp., with map, plate and illustrations. The subject is treated under four parts.

Part I contains "Introduction" and a "Brief review of the study of the Upper Devonian in New York." Under this heading the author gives a short summary and classification of the Upper Devonian as described by previous workers. Fig. 1, which closes the "first part," is made to represent three sections in the Upper Devonian, in different localities in New York state, giving the division of each and their correlation. (Naples section, Clarke. Ithaca section, Williams. Chenango valley section.)

Part II gives a detailed study and description of the sections made in and around Ithaca, with a list of the genera and species found in each section, closing with a "Table showing the range of some of the species of the Portage and Ithaca faunas at Ithaca, N. Y." This table is based on four sections in which the *Spirifer lævis* zone has been ascertained, as the author states, and is so arranged that the vertical range of each species in the group is referred to the *Spirifer lævis* bed of the Portage group.

Part III gives a "List of species occurring in the Portage and Ithaca groups, and a list of species given by others in the 'typical Chemung.'"

Part IV contains summary and partial bibliography.

The most important facts pointed out by the author in his study of the Itaca group are first, four faunas are represented in this group.

Secondly, the extent in "vertical range of some of the well known species" of the group faunas and the more definitely determining that of others. *Glyptocardia speciosa* and *Lunulicardium fragile*, two of the most abundant and characteristic Portage species, were found in the Ithaca group. The finding of a second *Spirifer lævis* bed located 110 feet below the zone at base of Ithaca falls. "The number of recurrent Hamilton fossils previously known from the Ithaca group has been increased by the discovery of some additional species," which are *Phacops rana, Orthis vanuxemi, Modiomorpha mytiloides, Nuculites triqueter, Strophodonta perplana, Phthonia cylindrica.*

Thirdly, a comparison shows that nearly all of the typical Portage species occur in the Ithaca fauna and some of the most abundant Ithaca fauna occur in the Portage, e. g., *Cyrtina hamiltonensis* and *Strophodonta mucronata.*

Fourth and lastly, a close relationship is found to exist between the faunas of the Ithaca and Chemung divisions, but not to the extent as between the Ithaca and Portage. The author concludes by stating, that because of the close relationship in the two faunas the Ithaca division should be classed in the Portage epoch.

Two new species are figured and described by Mr. Kindle, viz., *Bellerophon ithacensis*, n. sp., *Aviculopecten lautus*, var. *ithacensis*, n. var.

T. L. W.

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Bull. Geol. Soc. Amer., vol. 8, pp. 1-16, Dec. 31, 1896. Proceedings of the eighth summer meeting, H. L. Fairchild; Cuyahoga preglacial gorge in Cleveland, Ohio, Warren Upham; Origin of conglomerates of western Indiana, T. C. Hopkins.

III. Papers in Scientific Journals.

Nat. Geog. Mag., Nov. The economic aspects of soil erosion, N. S. Shaler.

Amer. Jour. Sci., Dec. Archelon ischyros: a new gigantic cryptodire testudinate from the Fort Pierre Cretaceous of South Dakota, G. R. Wieland; Examination of specimens from Chichan-Kanab, Yucatan, J. L. Howe and H. D. Campbell; Chemical composition of Hawaiian soils and of the rocks from which they have been derived, A. B. Lyons; The original Trenton rocks, T. G. White; Jurassic formation on the Atlantic coast, O. C. Marsh.

Science, Nov. 6. Current notes of physiography, W. M. Davis.

Science, Nov. 13. Honors to James Hall at Buffalo, W J McGee, J. M. Clarke, and others; Final summary report of the Geological Survey of Pennsylvania, E. V. d'Invilliers.

Science, Nov. 20. Current notes on physiography, W. M. Davis; Glaciers in the Montana Rockies, L. W. Chaney, Jr.

Science, Nov. 27 LeConte's Elements of Geology, C. W. Hall.

Science, Dec. 4. The Jurassic formation on the Atlantic coast, O. C. Marsh; Volcanic ash in southwestern Nebraska, R. D. Salisbury; Current notes on physiography, W. M. Davis.

Science, Dec. 11. Age of the Potomac formation, G. K. Gilbert; Le Conte's Elements of Geology, G. K. Gilbert.

Science, Dec. 18. Current notes on physiography, W. M. Davis; A question of classification, R. T. Hill.

Science, Dec. 25. Tapirs, past and present, Chas. Earle; The Jura in the United States. Jules Marcou.

Engineering and Mining Jour., Dec. 19. The limonites of Alabama geologically considered, Henry McCalley.

Ottawa Naturalist, Oct. Petrographical notes on some Archæan rocks from Chelsea, Que., J. A. Dresser.

Journ. of Geol., Oct.-Nov. Salient points concerning the glacial geology of north Greenland, R. D. Salisbury; Genesis of lake Agassiz, J. B. Tyrrell; Laccolites in southeastern Colorado, G. K. Gilbert; Italian petrographical sketches (II. The Viterbo region), H. S. Washington; The principles of rock weathering, G. P. Merrill; Editorial on nomenclature of glacial deposits in the Mississippi valley, T. C. Chamberlin.

Appletons' Pop. Sci. Monthly, Dec. Sketch of Henry Darwin Rogers; Igneous intrusions and volcanoes, I. C. Russell.

Amer. Naturalist, Dec. Fossils and fossilization, L. P. Gratacap.

Ottawa Naturalist, Nov., 1896. New species of graptolites from Canada. H. M. Ami.

Canadian Rec. of Sci., July, 1886. Canadian stromatoporoids, J. F. Whiteaves; Nematophyton crassum, D. P. Penhallow; Pre-Cambrian fossils, especially in Canada, J. W. Dawson.

Amer. Jour. Sci., Jan. Some queries on rock differentiation, G. F. Becker; On igneous rocks from Smyrna and Pergamon, H. S. Washington; Note on a new meteorite from the Sacramento mountains, Eddy Co., New Mexico, W. M. Foote; Catalogue of the collection of meteorites in the Peabody Museum of Yale University, H. S. Washington.

Science, Jan. 1. The geology of government explorations, S. F. Emmons; Current notes on physiography, W. M. Davis.

Science, Jan. 8. The geology of government explorations, S. F. Emmons; Volcanic dust in southwestern Nebraska and in South Dakota, J. E. Todd.

Science, Jan. 15. Geological Society of America, ninth annual meeting, J. F. Kemp.

Technological Quart., Dec., 1896. Origin of pegmatite, W. O. Crosby and M. L. Fuller.

Eng. and Mining Jour., Jan. 9. The hematites of Alabama geologically considered, Henry McCalley.

PERSONAL AND SCIENTIFIC NEWS.

The American Antiquarian (under the editorship of Rev. Stephen D. Peet, Good Hope, Ill.) will publish, during the present year, a series of articles, by different authors, on the relations of geology and anthropology.

Lehigh University has received from Mrs. Coxe, widow of the late Eckley B. Coxe, of Drifton, Pa., the technical library of Mr. Coxe. This library is especially rich in sets of various journals and transactions of scientific societies.

Joseph D. Weeks, editor of the *American Manufacturer*, died on Dec. 26th at Pittsburg, Pa. Mr. Weeks was known to geologists chiefly through his economic work for the U. S. Geological Survey which he began in 1885. In the 16th Annual Report of that survey he contributed papers (Mineral Resources) on manganese, petroleum, natural gas and manufacture of coke.

Glaciation in the Puget Sound region. During the past season the drift deposits about the southeastern edge of Puget sound have been studied in some detail. They are found to consist of several beds of till, separated by stratified deposits of clay, sand and coarse gravel, together with widely distributed lignite beds. The character and extent of the glaciation of the Puget sound region are indicated in these deposits, and it is found that the principal flow of ice was rather from the north than from the mountains on the southeast. Two problems are presented by the phenomena—(1) the sequence of glacial advance and retreat and the extent and duration of climatic changes indicated by the presence of lignites; (2) the bearing of the peculiar conditions of glacial development upon the physiography of the sound. Either the deeper valleys of the sound have been eroded during a period of high level from the once more extensive sheets of drift or, as suggested by Russell, the channels represent the beds repeatedly occupied by glaciers, which in their advance and retreat built up the plateau-like eminences of the region, probably upon the pre-existing topography. The past condition of Puget sound under confluent glaciation is probably now represented by the Malaspina glacier and its attendant phenomena.—*Bailey Willis.*

GEOLOGICAL SOCIETY OF AMERICA.

At the recent meeting, which was held at Washington, about 75 fellows were in attendance, and the Washington geologists gave the society a very warm welcome. Seven new fellows were declared elected by the ballot returned, and Prof. Edward Orton, of Columbus, O., was elected president. The report of the officers showed that the society is flourishing, financially and otherwise. Following is the list of papers presented:

JOSEPH LE CONTE—The different kinds of earth-crust movements and their causes. (President's address.)

J. S. DILLER—Crater lake. (30 minutes.) (Lantern views.)

J. F. KEMP—The Leucite hills, Wyoming. (15 minutes.) (Lantern views.)

N. H. DARTON—Physiographic development of the District of Columbia region. (30 minutes.) (Lantern views.)

N. H. DARTON—Dikes in Appalachian Virginia. (10 minutes.)

FRANK LEVERETT—On the changes of drainage in the Ohio river basin. (20 minutes.)

C. WILLARD HAYES—The solution of quartz under atmospheric conditions. (15 minutes.)

MARIUS R. CAMPBELL—Erosion at baselevel. (10 minutes.)

MARIUS R. CAMPBELL—The origin of certain topographic forms. (25 minutes.)

J. B. WOODWORTH—Homology of joints and artificial fractures. (10 minutes.)

ARTHUR KEITH—Notes on the structure of the Cranberry district in North Carolina. (15 minutes.)

C. H. HITCHCOCK—Notes on the stratigraphy of certain homogeneous rocks. (5 minutes.)

J. B. WOODWORTH—Unconformities in Marthas Vineyard and Block island. (20 minutes.)

ROBERT BELL—Evidences of northeasterly differential rising of the land along Bell river. (15 minutes.)

GEORGE E. LADD—Surface tension of water as a cause of geological phenomena.

ERASMUS HAWORTH—Cementing materials of the Tertiary sands and gravels of western Kansas. (15 minutes.)

H. W. TURNER—The work of the U. S. Geological Survey in the Sierra Nevada.

J. W. SPENCER—Geomorphy of Jamaica as evidences of changes of level. (Read by title.)

RALPH S. TARR—The Cornell glacier, Greenland. (20 minutes.)

H. L. FAIRCHILD—Shorelines of lake Warren and of a lower water level in western-central New York. (10 minutes.)

G. K. GILBERT—Old tracks of Erian drainage in western New York. (30 minutes.)

ANGELO HEILPRIN—The assumed glaciation of the Atlas mountains of Africa.

FRANK LEVERETT—The relation of an abandoned river channel in eastern Iowa to the western edge of the Illinois icelobe. (15 minutes.)

GEORGE H. BARTON—Glacial observations in the Umanak district, Greenland. (30 minutes.)

F. B. TAYLOR—The Nipissing-Mattawa river, the outlet of the Nipissing great lakes. (20 minutes.)

F. B. TAYLOR—Moraines of recession and their significance in glacial theory. (20 minutes.)

HARRY FIELDING REID—Mechanics of glaciers—moraines and stratification. (20 minutes.) (Lantern views.)

HARRY FIELDING REID—Variations of glaciers.

BAILEY WILLIS—Preliminary note on the Pleistocene history of Puget sound.

WARREN UPHAM—Modified drift in St. Paul, Minnesota. (20 minutes.)

I. C. RUSSELL—Notes on plasticity of glacial ice. (6 minutes.)

CHARLES R. KEYES—Physical basis for general geological correlation. (10 minutes.)

F. D. ADAMS and A. E. BARLOW—Origin and relations of the Grenville-Hastings series in the Canadian Laurentian, with observations by R. W. ELLS.

J. F. KEMP—The pre-Cambrian topography of the eastern Adirondacks. (20 minutes.)

J. E. WOLFF and A. H. BROOKS—The age of the white limestone of Sussex county, New Jersey. (25 minutes.)

JOSEPH F. JAMES—Notes on the Potsdam and Lower Magnesian formations of Wisconsin and Minnesota. (10 minutes.)

HENRY S. WILLIAMS.-On the southern Devonian formations. (25 minutes.)

I. C. WHITE—A complete oil well record in the McDonald field, between the Pittsburgh coal and Fifth Oil Sand. (Read by title.)

DAVID WHITE—The age of the lower coals of Henry county, Missouri. (15 minutes.)

HENRY B. KÜMMEL—Structure of the Newark formation of western New Jersey. (20 minutes.)

WILLIAM B. CLARK—The Upper Cretaceous formations of the northern Atlantic coastal plain. (20 minutes.)

T. W. STANTON and F. H. KNOWLTON—Notes on the stratigraphy and Paleontology of the Laramie and related formations in Wyoming. (30 minutes.)

I. C. RUSLELL—Geology of northeastern Washington. (20 minutes.)

E. H. BARBOUR—A study of the nature, structure, and phylogeny of Dæmonelix. (60 minutes.) (Lantern views.)

GEORGE P. MERRILL—Notes on rock weathering. (20 minutes.)

HENRY B. KÜMMEL—New evidence on the origin of some trap sheets of New Jersey. (10 minutes.)

C. WILLARD HAYES and ALFRED H. BROOKS—The crystalline and metamorphic rocks of northwest Georgia. (30 minutes.)

ALFRED C. LANE—The grain of rocks. (25 minutes.)

G. PERRY GRIMSLEY—The origin and age of the gypsum deposits of Kansas. (Read by title.)

FLORENCE BASCOM—Notes on the Pre-Cambrian volcanics of South Mountain, Pa.

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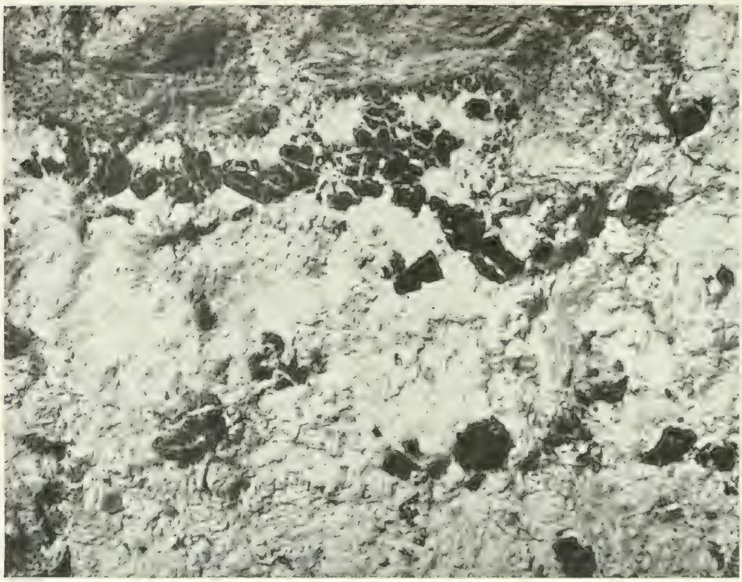

FIG. 1.--TOURMALINE IN PEGMATITE ON AND NEAR THE WALL-ROCK (MICA SCHIST).
CHANDLER'S MILLS, N. H.

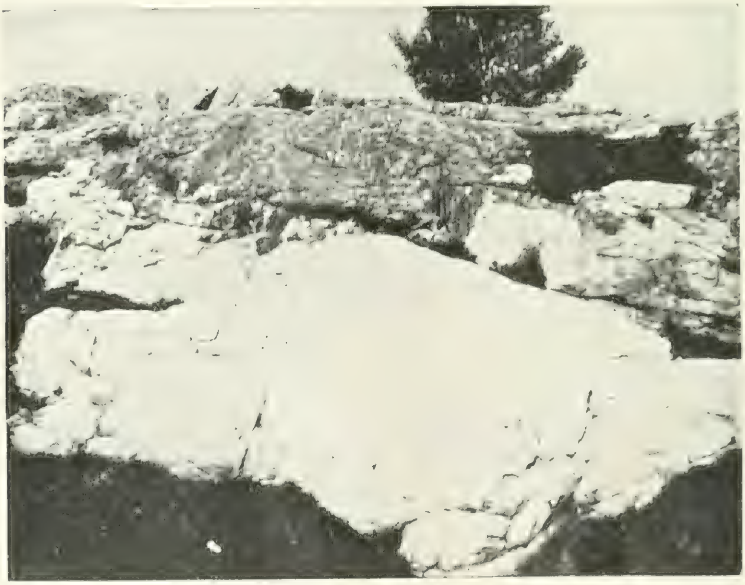

FIG. 2.—MASS OF QUARTZITE IN PEGMATITE. OSGOOD'S LEDGE, ACWORTH, N. H.

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THE

AMERICAN GEOLOGIST.

VOL. XIX. MARCH, 1897. No. 3

ORIGIN OF PEGMATITE.

By W. O. CROSBY* and M. L. FULLER, Boston, Mass.

[From the Mass. Inst. Technology Quarterly, vol. IX, pp. 326-356, Dec., 1896.]

INTRODUCTION.

The history of geology is replete with theories of pegmatite, or giant granite—manifold modifications of the agency of water and heat; and this diversity of opinion finds a ready explanation in the fact that in no other class of rocks do we find such a perfect combination of aqueous and igneous characters. Although the intimate association and evident close connection of pegmatite with undoubted plutonic rocks, and

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*Nearly three years ago (December, 1893) I read a paper on the "Origin of Pegmatite" before the Geological Society of America, a brief abstract of which appeared in the AMERICAN GEOLOGIST for March, 1894. (See, also, Mass. Inst. Technology Quarterly, vol. 7, pp. 30-31.) In that paper I developed in outline the modification of Lehmann's aqueo-igneous theory of pegmatite, which is more completely elaborated and substantiated in the present contribution; but its publication was deferred, awaiting an opportunity to more thoroughly test the theory in the field. In the summer of 1895 I was able to spend a few days in the pegmatite district of Grafton and Sullivan counties, in southwestern New Hampshire, and later in the year Mr. Fuller, a student in the Geological Department of the Massachusetts Institute of Technology, undertook, under my direction, a more extended and detailed study of the pegmatites of that region, basing thereon his thesis for graduation the following June. Mr. Fuller's investigation has materially modified and strengthened the aqueo-igneous theory, and hence this joint production.
W. O. CROSBY.

their agreement with the latter in composition and relations to the inclosing formations, has led many writers to regard the pegmatite itself as of plutonic igneous origin, it is not long since geologists, from a consideration chiefly of the exceedingly coarse crystallization and frequent comb-structure of the pegmatites, were quite generally united, under the leadership of T. Sterry Hunt, in the conviction that they were true vein rocks, due to the deposition of the various component minerals from solution in open fissures or other preëxisting cavities. Now, however, a decided drift in the opposite direction may again be noted, and the recent literature of the science indicates an approaching consensus of opinion in favor of the association of the pegmatites, in their genetic relations, with plutonic igneous rocks rather than with subterranean aqueous deposits. In fact, the view that pegmatite is in some sense an intrusive rock may be regarded as so well established, through the labors of Lehmann,* Brögger,† Williams,‡ and others, that the theories of lateral secretion and aqueous deposition are fast becoming of merely historical interest.

This modern view is more acceptable than any of its predecessors mainly because it is less extreme. It is a reaction toward the igneous category, but the pendulum has not swung so far as to wholly exclude the aqueous influences. In short, the new theory is not simply a revival of the old, but it is essentially a combination or compromise—neither igneous nor aqueous, but aqueo-igneous. The modern conception is that in a broad view the pegmatites are igneous rocks, but it is the part which water has played in their formation that has so strongly differentiated them from other igneous types. Although we shall incidentally apply the touchstone of observed facts to all the principal hypotheses, the chief purpose of this paper is a contribution to the aqueo-igneous theory.§

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*Ueber die Entstehung der alt krystallinischen Schiefergesteine,1884, p. 24 *et seq.*

†Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit und Nephelinsyenite, I, Theil. pp. 215-225. For translation, by N. N. Evans, see Canadian Record of Science, 6, 33-46 and 61-71

‡"Origin of the Maryland Pegmatites." Fifteenth Annual Report United States Geological Survey, pp. 675-684.

§The contributions of Brögger and Williams, already referred to, are replete with references and render citations of the earlier literature unnecessary here.

The term pegmatite has been employed heretofore in two senses: To designite (1) the macro- and micro-pegmatitic or graphic-granite structure in rocks; (2) a distinct type of coarsely crystalline plutonic rocks, which is characterized only to a slight degree by the pegmatitic or graphic structure, but is especially distinguished, as a rule, by the gigantic scale of its crystallization. It is, of course, in the second sense that the term is employed here. We desire, however, to direct attention at the outset to two prominent facts which appear to us to demand a modification of the definition. First, the pegmatites have a wide range in composition, from the most highly acidic of all rocks (pure quartz) to ultra-basic varieties, giant granite being an appropriate trivial name only for some of the more acid forms. Second, the differences between the pegmatites and the more normal plutonic rocks are textural to a much greater degree than mineralogical or chemical. In other words, since the classification is based primarily upon composition (the result of magmatic differentiation), pegmatite should be regarded, not as a distinct species or family of rocks, but rather as a possible textural phase of all, or nearly all, the plutonic rocks; and we may in general say of any plutonic rock that it may be cryptocrystalline, microcrystalline, macrocrystalline, or pegmatitic. Our problem is, then, to account for the pegmatitic phase of the plutonic rocks. While there can be little or no doubt that the acid and basic pegmatites have had a common origin, every student of geology knows that the acid types have been far more generally and extensively observed and exploited, and hence more fully and satisfactorily described, and our own field studies, as already indicated, have been limited chiefly to this class. The conclusions stated in the following pages are to be understood, therefore, as applying especially to the acid pegmatites.

CHARACTERS OF THE ACID PEGMATITES.

A complete description of the acid pegmatites is not intended here, but simply an enumeration of the chief features which any satisfactory theory of their origin must explain.

Composition.—The acid pegmatites, like the corresponding normal plutonic rocks, consist of anhydrous silicate species, and usually more or less of free acid (quartz) and traces of free bases (iron oxides, cassiterite, etc.), apatite being, perhaps, the most conspicuous exception, although the complete list of the pegmatite minerals includes also titanite and various niobates, tantalates, and tungstates. The great disparity as regards abundance makes possible a quite sharp distinction between the so-called principal or essential, and the rarer or accessory, species. The essential species include quartz; the acid feldspars—orthoclase, oligoclase, albite, and microcline—the last two being especially characteristic; and the more acid micas, including muscovite and lepidolite and, less characteristically, biotite. The accessory minerals are more numerous, in some cases more distinctive, and especially remarkable for the large proportion of rare species or species that are rare or wholly wanting in other rocks. A single mica mine in New Hampshire (the Ruggles mine in Grafton) is said to have afforded sixty-one minerals, and it is undoubtedly true that the list of known silicate species is considerably longer than it would be if these natural cabinets, or storehouses of fine minerals, had never been studied.

The quartz of pegmatite, as of ordinary granite, is especially characterized by numerous inclusions of water and carbon dioxide. The proportion of carbon dioxide to water has been proved to be so high in some cases—for example, nearly 1 to 1 in the quartz of the Branchville, Connecticut, pegmatite—as to indicate that the crystallization took place under enormous pressure.*

Our observations abundantly confirm Williams' statement† that the most typical pegmatites are intimately associated with, and pass gradually into, bodies of pure quartz and ordinary quartz veins. But we cannot agree with this writer in drawing across this undoubted gradation an arbitrary line of demarcation as regards origin. On the contrary, we feel that the true theory of pegmatite must recognize this obvious relationship to quartz veins, by making of the latter a possible end-product of the same great process of differentiation which yields the former. In other words, some quartz veins are on the same road that lead to pegmatite, but a little farther along, at the end of the road. On the west side of Narragan-

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*A. W. Wright, American Journal Science, March, 1881.

†United States Geological Survey. Fifteenth Annual Report, pp. 678 and 679.

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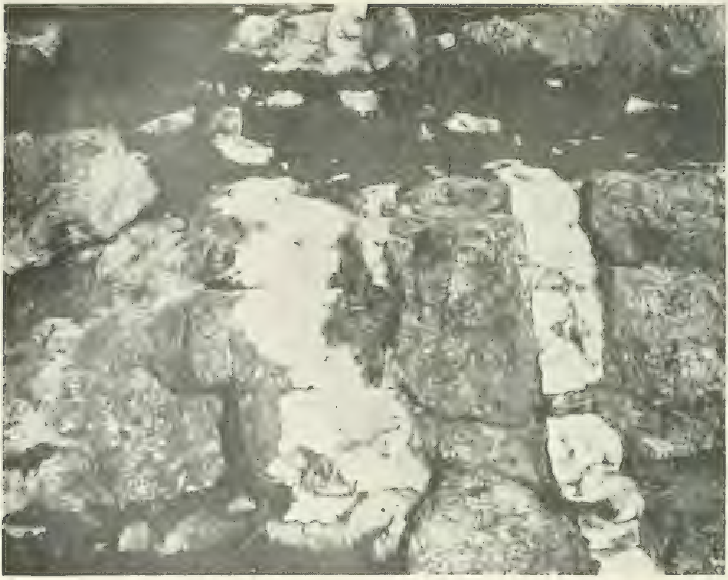

FIG. 3.—VEINS OF QUARTZ IN PEGMATITE. OSGOOD'S LEDGE. ACWORTH, N. H.

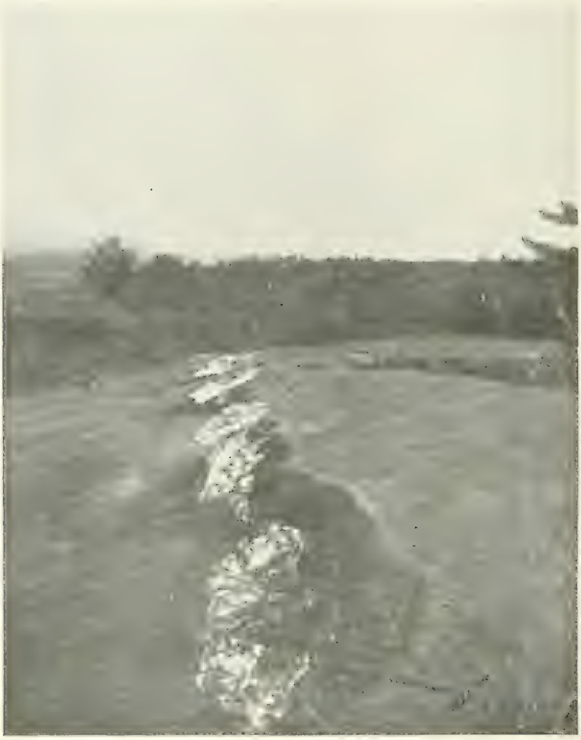

FIG. 5.—LENSES OF PEGMATITE IN WINNEPESAUKEE GNEISS.
HONEY BROOK LEDGES, ACWORTH, N. H.

sett bay, opposite Conanicut island, there is, in the cliffs known as the Bonnet and Packard rocks, a series of mica schists backed by normal granite and traversed by numerous very typical veins of pegmatite 5 to 50 feet wide. A mile to the eastward, on Dutch island, the veins in the schist are quartz with some feldspar, but no mica; while on the west shore of Conanicut island, so far as observed, they are quartz alone. Van Hise has noted a similar gradation in the character of the pegmatite veins intersecting the schists which envelop the granite core or batholite of the Black Hills, the veins changing gradually from typical pegmatite near the granite to ordinary quartz veins at a moderate distance. *16th Annual Report, United States Geological Survey*, Part I, p. 688.

Relations of Composition to the Inclosing Rocks.—Broadly speaking, the pegmatites are independent of the wall rock in composition. In New Hampshire we have found pegmatites of strikingly uniform composition traversing in succession and without sensible change a whole series of granites,gneisses, and schists of the most diverse character. Brögger and Williams have specially noted this indifference of the pegmatites to the character of the inclosing formations. The former* cites as examples the acid pegmatites of Hitterö, which cut a very basic (labradorite and anorthite) rock, and those of Rudemyr cutting Silurian schists and limestones, and the latter† speaks of the acid pegmatites of Maryland as occurring in gabbro and peridotite and extending from gneiss into limestone without sensible change.

The one important exception to this principle is found in the fact which lies at the foundation of the modern theory of pegmatite, viz., that in every pegmatite district there is one normal plutonic rock of essentially similar but slightly less acid composition, with which the pegmatite is most intimately associated, into which it may often be traced, and from which it has evidently been derived. That is, the pegmatites are contrasted with the inclosing formations in all cases except where they traverse the plutonic mass of which they are the most highly differentiated phase or end-product. Brögger and

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*Canadian Record of Science, 6, 36 and 37.

†U. S. Geol. Survey, Ann. Report, 15, 683.

Williams lay much stress upon this fact and cite abundant illustrations of it, noting especially that the pegmatite is more acid than the parent mass. Williams says of the pegmatite dikes of Maryland, "They agree essentially in chemical and mineral composition with the granite masses whose igneous origin is well established, although they are in the main somewhat more acid than these, and their size and abundance are directly proportioned to their nearness to some eruptive granite mass. At many localities they can be seen to decrease steadily both in number and size, as they recede from such a granitic boundary." The more acid character of pegmatite than of granite is seen in the fact that among the micas biotite largely predominates in granite, and is the exception in pegmatite.

The parent plutonics of the pegmatites which we have studied in New Hampshire are the Concord granite, and the Montalban gneiss, the latter seeming to be merely a more gneissoid phase of the former. These two granitic types, it may be added, are readily proved by the field evidence to be the youngest and most acidic of the entire granite series of the region, the fact pointing very plainly to a progressive chemical differentiation of a vast body of magma during a long period, with, at the end, a marked textural differentiation. In New Hampshire we have not found the pegmatite so abundant in the Concord granite or any plutonic formation as in the fibrolite and other schists, which are easily proved to antedate all these igneous rocks. This is due in part, probably, to the fissile and flexible character of the schists, by virtue of which they offer an easier passage to intrusives than do the more massive formations; and in part, no doubt, to the relative readiness with which they are dissolved or melted away by the invading magma. It may be added that in the schists, as in the gneisses and granites, the amount of pegmatite is, in general, inversely proportional to the distance from the Concord granite.

It is a reasonable expectation that the absorption of great bodies of schist should affect the composition of the pegmatite. In fact, Geikie says (*Text-Book of Geology*, p. 302) igneous rocks dissolve or eat away the inclosing formations, and in consequence vary considerably in composition from place to place. The schists are poor in alkalies, being composed chiefly of silica and alumina; and their absorption by the pegmatite magma would obviously tend to make the pegmatite richer in quartz and muscovite, as the following comparison of the alkaline silicates shows, the formation of a pure aluminum silicate being impossible in the presence of alkalies.

Orthoclase, SiO_2, 64.7; Al_2O_3, 18.4; alkalies, 16.9.
Muscovite, SiO_2, 46.5; Al_2O_3, 33.9; alkalies, 10.0.

This is in harmony with our observation that the mica mines of New Hampshire, and so far as we are able to learn of other regions, are chiefly in the schist series, and we believe that in general the pegmatite is more micaceous in the schists than in the granite. It may be that we have here an explanation of greisen—that rather anomalous aggregate of quartz and mica. Lepidolite has been noted as a specially characteristic feature of pegmatite, and the fact that it also occurs in greisen is certainly suggestive of the genetic relationship of the two rocks. We also venture the suggestion that perhaps pegmatite rich in tourmaline, and tourmaline or schorl rock (tourmaline and quartz) may be explained in the same way, tourmaline representing a still greater dearth of alkalies—2 to 4 per cent.

Although this close agreement in composition between pegmatite and its parent plutonics certainly holds for the principal component minerals, the two types seem to be contrasted as regards their rarer or accessory constituents, pegmatite being much richer in these than granite. G. vom Rath, in his account of the celebrated pegmatite veins of Elba,* says that the "tourmaline, beryl, lithia, mica, etc., are foreign to normal granite," and that "these veins, on account of their wealth in rare and peculiar minerals, which for the most part are wanting in the wall-rocks, necessitates the assumption of a special mode of formation quite different to that assumed for the wall-rock." That the rare species are a more conspicuous feature of pegmatite than of granite is obvious, but that they are much more abundant when large volumes of rock are compared, has certainly not been proved, and is at least doubtful.

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*Die Insel Elba (Geogn.-min. Fragmente aus Italien, VIII) in Zeitschr. d. d. geol. Ges., 1870, 22, 649.

The same slow process which builds the giant crystals of spodumene, beryl, etc., must tend to gather the materials from a large volume of magma. In other words, although in the number and variety of the accessory minerals the pegmatite veins far exceed the known species of the normal granites, we have good reason for believing that in these rarer or accessory, as well as the more abundant or principal minerals, the two types are essentially similar if not almost identical, or at least that bulk analyses would show a substantial agreement in chemical composition. Substances which are so sparingly and thinly diffused in the normal granites as to be almost inappreciable are, if not actually concentrated in the pegmatite, developed in a more concrete and tangible form.

Texture. (*Crystallization.*)—Undoubtedly the most distinctive and striking feature of the pegmatites is the crystalline structure, which is, in general, on a remarkably coarse or gigantic scale, and unparalleled among the sedimentary and normal igneous rocks. Well formed crystals of feldspar and mica, and even of such rare accessories as beryl and spodumene, from 6 inches to a foot or more in diameter, are normal occurrences. In fact, as regards the size, perfection, beauty, and variety of the specimens which they afford, the pegmatites are, more than all other rock formations taken together, the great repositories of crystallized silicates, as every good mineral cabinet testifies; and it is thus easy to understand why the pegmatite veins are objects of the highest interest to students of mineralogy. An examination of the mineral localities of New England and Canada, not to take a broader view, would undoubtedly show that a very large majority of the most interesting occurrences are in acid or basic pegmatites.

The maximum crystallization is indicated by the great beryls from a foot to a yard in diameter in the mica mines of New Hampshire, the largest known example of which is in the Museum of the Boston Society of Natural History, and the gigantic spodumenes from 10 to over 30 feet in length, and from a foot to a yard in diameter, in the tin mines of the Black Hills. In the pegmatites of New Hampshire we have frequently observed feldspars ten feet or more in length, and one crystal in the American mine in Groton measured fully

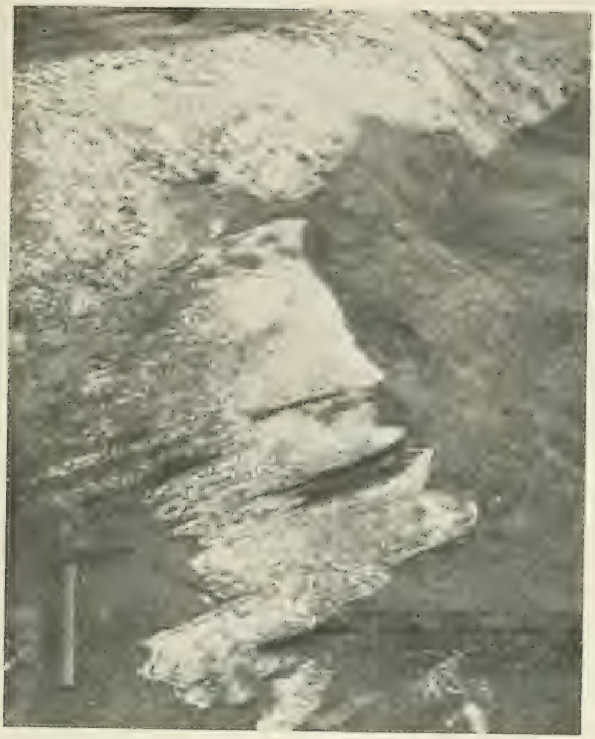

FIG. 6.—IRREGULAR VEIN OF PEGMATITE IN WINNEPESAUKEE GNEISS. HONEY BROOK LEDGES, ACWORTH, N. H.

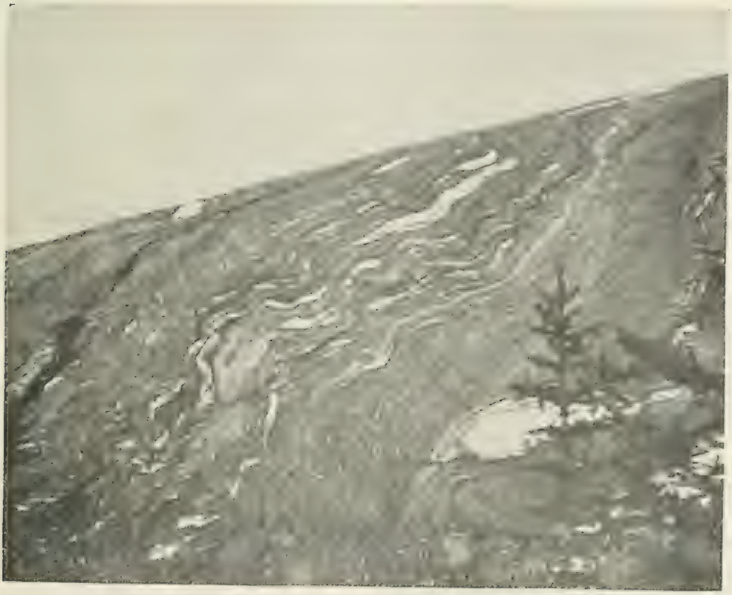

FIG. 8.—VEINS OF QUARTZ AND PEGMATITE IN MICA SCHIST. CROYDON MT., GRANTHAM, N. H.

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20 feet; while Brögger mentions* feldspar individuals more than 10 meters (nearly 33 feet) in length. It is, of course, by virtue of the large scale on which the crystallization has taken place that the pegmatite veins are not quarried for granite, but rather to obtain mica, feldspar, and quartz for commercial purposes, these and many rarer species for mineral cabinets, and tourmaline and other gems.

Brögger† also points out that coarseness of crystallization alone does not "condition the pegmatitic nature of the veins, nor is even necessarily present in order to justify the appelation pegmatitic. It is the habitus as a whole which determines this." Nevertheless, this giant granite texture is very constant, and clearly, as already stated, the most distinctive and essential character of pegmatite. One fact to be specially noted is that the coarseness of texture or scale of crystallization is not proportional to the size of the masses, for dikes and bosses hundreds of feet wide may be finer grained than those 5 to 20 feet wide. Thus the great boss of pegmatite forming Mt. Tug, in Orange, 500 feet wide and 1,500 feet long, is relatively fine-grained, while, marking the other extreme, we recall a vein in Groton less than 2 feet wide containing stout crystals of feldspar 20 inches broad.

Next in order stands the irregularity of both the mineral composition and texture. The normal plutonics are remarkably even grained and uniform mixtures of the component minerals; but in the pegmatites the principle of segregation has evidently had almost unrestricted play, and irregularity is the rule. It is difficult to do justice to this somewhat indefinite character in words; but every one who has observed pegmatites in the field will fully appreciate it. As noted by Brögger,‡ the finer grained portions of the pegmatite often become eugranitic and indistinguishable from the parent plutonic.

The order of crystallization of the various minerals in pegmatite is the same as for the normal plutonics—tourmaline (and other basic species), biotite, muscovite, basic feldspar, acid feldspar, and quartz—and equally constant (Fig. 1, Pl. VII). Pegmatite agrees with the normal plutonics, also, in the approximately idiomorphic character of the earlier crystallizations, the quartz being always allotriomorphic. In the vugs and pockets of the pegmatite veins, however, the order of crystallization is reversed, except for tourmaline and other ultra-basic species, and the quartz is idiomorphic. This reverse order is well shown in the abundant association of albite and muscovite in the pockets of the pegmatite veins of Groton, Orange, Grafton, and other towns. The albite occurs as distinct tabular crystals (clevelandite) projecting into the cavity; and implanted on the albites are the muscovites. Notwithstanding the lateness of the crystallization,the quartz not unfrequently forms immense vitreous *masses* (Fig. 2, Pl. VII), and these often pass into veins of quartz, or quartz and accessory feldspar, intersecting the normal pegmatite as well as the country rock (Fig. 3, Pl. VIII), thus testifying clearly to the extremely acid character of the magma residuum.

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*Canadian Record of Science, 6, 67.

†Ibid., 69 and 70.

‡Canadian Record of Science, 6, 64.

Rosenbusch has sagaciously correlated the pockets and druses with the miarolitic structure of the normal plutonics —a feature of like significance, but developed, like the crystallization, on a grand scale. Evidence of contemporaneous crystallization is abundant in all the larger masses, the crystallization of the later species having begun before that of the earlier ceased. It is sufficient to merely mention the unique example of this which we have in graphic granite. A tendency to this regular intergrowth of quartz and feldspar is frequently manifested; but it rather rarely attains to its ideal development. The perthitic intergrowth of the feldspars has, apparently, a like significance. When the earlier crystallizations assume slender, prismatic forms, as is notably the case with tourmaline, the subsequent hardening and crystallization of the silica (quartz) involves not only the inclosure, but also the distortion and breaking of the guest crystals.

Structure.—It is among the varied structural phases of pegmatite that aqueous and igneous characters—the features of veins and the features of dikes—are most perfectly blended. The pegmatite masses, like true dikes, are frequently fine-grained next the wall, becoming rapidly coarser toward the center. Where the inclosing formation is the parent plutonic, the fine-grained portion, as previously noted, sometimes becomes eugranitic and grades into the wall-rock without any line of demarcation. This contact zone of the pegmatite masses is, perhaps, the most usual phase of the banded structure to which the advocates of the aqueous theory attach so much importance. Brögger says,* "The zonal structure, when any such is present, which, however, is generally not the case, usually makes itself evident only in a finer-grained condition of the vein boundaries, and sometimes (especially in the case of granitic pegmatite veins) in a zone with graphic structure next the fine-grained eugranitic marginal zone, upon which there frequently follows (especially in acid granitic pegmatite veins) in the middle of the vein a tremendous size of grain, here often with special enrichment in rarer minerals and also (particularly in acid veins) not seldom with open or distinctly drusy cavities filled with peculiar mineral deposits." All this accords with our observations; but, besides this pseudo-banding, there is a true vein-banding closely akin to that of undoubted aqueous formations. This, however, is of rather rare occurrence; and, according to our observations, mostly confined to the narrow, linear, crack-filling veins, such as abound in the Concord granite. We are unable to agree with Brögger that this banding is always distinct from that of true veins, "inasmuch as the outer zones pass continuously into the inner." We will only cite a single instance; but this appears to be typical. In the Museum of the Boston Society of Natural History is a complete cross-section specimen from a well-defined linear vein of pegmatite in Chesterfield, Mass. The width of the vein is six to seven inches: and it is made up of two sharply defined and symmetrical bands or layers of albite (clevelandite), with the tabular crystals set edgewise to the walls, and a median band of smoky quartz: while springing directly from either wall and penetrating both the albite and quartz are numerous slender prisms of green and red tourmaline. The order of crystallization is clearly marked; and it is very obvious that in this instance the successive periods or generations did not overlap. The minerals were deposited strictly in succession, although for that matter a certain amount of contemporaneous deposition is common enough in true veins.

The disposition of the tourmalines noted above is highly characteristic; and may be observed in many massive or unbanded veins; showing that this comb-structure and a distinct banding are not necessarily correlative, although they are undoubtedly of like significance; testifying with equal distinctness to successive crystallization. The comb-structure is also observable in the disposition of other prismatic minerals and of such tabular species as mica and albite, which are almost invariably set edgewise or perpendicular to the walls in veins of regular form and structure.

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*Canadian Record of Science, 6, 66.

Although occurring but sparingly, vugs or pockets and druses are to be regarded as highly characteristic and significant structural features of pegmatite—interesting and entirely normal possibilities of the pegmatite process. In the New Hampshire pegmatites we have found them almost exclusively in the larger veins and masses; and some of these are of large dimensions, as may be inferred from the fact that a pocket in the Palermo mine, in Groton, has afforded a well-formed crystal of quartz about a yard in diameter. These great pockets are wholly irregular in form, and seem to have no definite position in the vein, except that they are never peripheral. In other districts, pockets in narrow and distinctly linear veins have been observed. These are flatly lenticular in form and, except mineralogically, in no wise distinguishable from the pockets of ordinary mineral veins.

Inclosed fragments of the wall-rock are an exceedingly common and characteristic feature of pegmatite; and the inclusions are, almost without exception, as so commonly in the normal plutonic rocks, in perfect agreement in position and orientation of the lamination or other structural features with the adjacent wall-rock. This peculiarity of the inclusions, although not absolutely incompatible with the aqueous theory of pegmatite, certainly accords best with the plutonic igneous theory. In two instances only have we observed inclusions that appeared to be foreign to the immediately adjacent part of the wall; viz., in small veins near the Palermo mica mine of North Groton and in the southern part of Grafton. In both cases the foreign inclusions are of the dark hornblendic Bethlehem gneiss, while the wall-rock is fibrolite schist in the first instance and the coarse porphyritic granite in the second.

In many cases the inclusions, especially of schist, have an exceedingly frayed-out and skeleton-like appearance, suggesting a differential solvent action and shredding rather than mere mechanical breaking or cracking. The wall itself is often similarly affected, as well as more or less distinctly impregnated with tourmaline and other minerals of the first crystallization. This is perhaps the most significant of all the contact phenomena coming under our notice.

We have not observed any clear examples of the centric or spheroidal structure described by L. von Buch and others, and so strongly insisted upon by Brögger; nor has the rare fluidal structure cited by Brögger* come under our notice. But we have noted one fact which very plainly suggests motion in the mass during the crystallization of the pegmatite. In a small vein in the Winnepesaukee gneiss north of Honey Brook, in Acworth, the tourmalines, which extend about two-thirds of the way across the fissure, are for a distance of many feet tilted uniformly from the perpendicular to the wall about thirty degrees. This tilting is real and cannot be explained by any irregularity of the walls.

External forms and formal relations to inclosing rocks.—With pegmatite, as with pretty much all subterranean formations, form is less distinctive and significant than structure or composition; and the morphologic argument is rather evenly divided between the rival theories—aqueous and igneous. In general, the occurrences are dike-like in form; but they may with equal propriety be described as vein-like.

No doubt the spaces or cavities occupied by the pegmatites are chiefly mechanical in origin—spaces of discission; and they must, therefore, be conditioned by the structure of the inclosing rocks and the nature of the disrupting force. The more regular masses may be described as rectangular (Figure 4), wall-like (vertical sheets), lenticular (Fig. 5, Pl. VIII), or tabular (horizontal sheets); but a very large proportion of the occurrences are too irregular to come under either of these terms (Fig. 6, Pl. IX). They very commonly conform closely with the structure planes of the schistose rocks (interbedded veins); but they also intersect the bedding planes or lamination at all angles; and may in general be assumed to follow lines of least resistance to the disrupting force.

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*Canadian Record of Science, 6, 64 and 65.

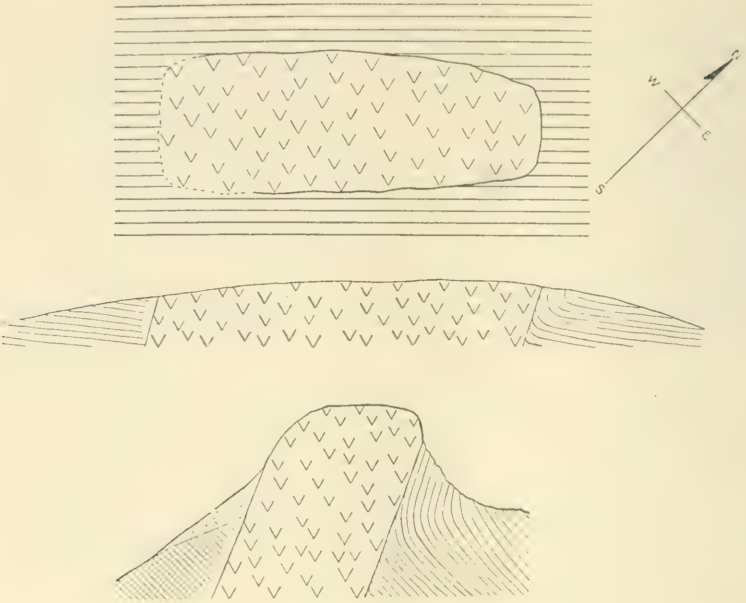

FIG. 4.—Plan and Sections of the Great Vein of Pegmatite forming Osgood's Ledge, Acworth, N. H. One inch = 400 feet.

We were surprised to find that the cavities occupied by the pegmatite are, on the whole, more crack-like (parallel sides, definite angles, and general linear character) and more plainly suggest a mechanical or disrupting force in the massive rocks than in the bedded and schistose rocks; and for many of the pegmatite masses in the schists the mechanical explanation is entirely inadmissible, the pegmatite having evidently made room for itself by dissolving and absorbing considerable volumes of schist—spaces of dissolution. We have a magnificent example in the great body of pegmatite at Ruggles Mica mine, in Grafton. It has great breadth in the vertical schists, and the schists, without change of dip, completely cover the pegmatite, the bedding planes ending downwards squarely against the approximately flat upper surface of the great boss of stock of pegmatite (Figure 7). Evidently, no theory of pegmatite can be regarded as adequate which fails to take account of both of these diverse causes of the cavities—rifting and solu-

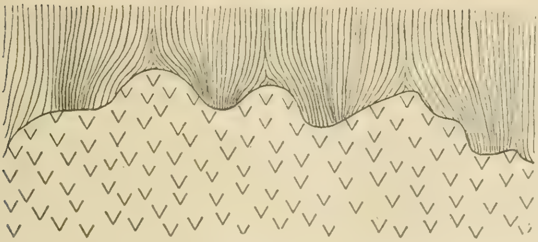

FIG. 7—Vertical Section of Pegmatite and Overlying Schist, Ruggles Mine, Grafton, N. H.

tion*. Still a third cause must be invoked where the pegmatite is inclosed in, and blends with, the parent plutonic rock.

Although, as indicated, certain more or less definite terms may be applied to the pegmatite masses, the great majority are decidedly irregular and indefinite in form. In every instance the pegmatite is clearly younger than the foliation of the inclosing rocks. The masses vary in size from almost microscopic veinlets, which, as Williams† has pointed out, show a high degree of liquidity in the original magma, up to bosses or dikes 500 feet or more, in width. So far as we have observed, the largest masses show a tendency to the rectangular type. These include Mt. Tug, Orange, 500 × 1,500 feet; Osgood's Ledge, Acworth, 175 × 700 feet; Palermo mine, Groton, 200 × 500 feet.

Some of the rectangular forms are probably blunt lenses. The lenticutar form is also very typically developed in some of the larger masses, such as the great veins on Crystal mountain, Lempster, 80 × 300 feet, and Trow's hill, Sunapee, 50 × 400 feet. We have already noted that the pegmatite dikes become smaller and fewer away from the parent mass of granite. The minor lenticular veins, isolated lenses or eyes, conforming with the foliation of the schists, present an interesting problem as to the source and mode of introduction of the component minerals (Fig. 8, Pl. IX).

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*According to the observations of Delesse, volcanic rocks, when reduced to a molten condition, attack briskly the sides of the Hessian crucibles in which they are contained and even eat through them.

†U. S. Geol. Survey, Annual Report, 15, 681.

AQUEOUS THEORIES.

All subterranean aqueous deposits may be referred to three classes: veins, impregnations, and substitution deposits.* The second and third classes may safely be set aside at once as incapable of throwing any light upon the origin of pegmatite; unless, indeed, the solution and absorption of a body of schist by molten magma be regarded as a mode of substitution. It is sufficient for our present purpose to recognize the two main types of veins: (1) endogenous veins formed chiefly by ascending solutions in fissures or cavities; (2) exogenous veins, formed chiefly by lateral secretion in rocks devoid of sensible fissures or cavities. The characters of the endogenous or fissure veins are well known, the most significant perhaps, being the banding or crustification, comb-structure and pockets. The exogenous or segregation veins are especially characterized by their homogeneity of composition and structure and the absence of pockets.

The view that pegmatite masses are, in origin, akin to mineral veins, originally proposed by Saussure, has in recent years been most positively asserted and strongly defended by T. Sterry Hunt. He held† that the pegmatites have been formed by the successive deposition of mineral matter from solution, usually in open fissures; and in the development of the crenitic hypothesis‡ he states that "the gneisses and bedded granites are to granitic veins (pegmatite) what beds of chemically deposited limestone and travertine are to calcareous veins."

In reviewing the characters of pegmatite, a goodly portion are found to be common to one or the other of the two types of veins noted above; and to admit of explanation, therefore, by the purely aqueous theories. Among these are the following: (1) rare minerals; (2) coarse crystallization; (3) banding and comb-structure, with tourmalines, etc., normal to the walls; (4) inclusions of water in quartz, etc.; (5) pockets and druses. On the other hand, vein formation does not satisfactorily explain: (1) the order of crystallization, except in pockets; (2) completely idiomorphic crystals; (3) the graphic structure; (4) the finer crystallization next the walls, at least this is more suggestive of igneous contacts; (5) broken tourmalines, etc.; (6) inclined tourmalines; (7) inclusions of carbon dioxide; (8) immense size of many of the veins; (9) evidence of solution of the walls; (10) orientation of inclusions. The characters of the first list point unequivocally to the intervention of water in the formation of pegmatite; while those of the second list demand with equal distinctness important modification of the aqueous process.

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*Technology Quarterly, 7, 27-48.

†Notes on Granitic Rocks, Amer. Jour. Sci., III, 2, 89.

‡Mineral Physiology and Physiography, 1886, 133.

IGNEOUS THEORIES.

One of the earliest, and at the same time one of the clearest and most satisfactory, statements of the igneous theory of pegmatite is that by Charpentier (1823). He held that the pegmatites are "injections of granitic material, which, originating in the still fluid granite, deep down, was pressed into the cracks of the already solidified granite above—afterbirths, as it were, of the same granitic formation in the district of which they occur."

This idea was accepted by De la Beche, Bronn, Fournet, Durocher, and Angelot; and Naumann* regarded it as the most probable theory.

Brögger quotes Charpentier's view approvingly; and his own paper, one of the most notable of the later contributions to the literature of pegmatite, is essentially a defense and farther development of this early igneous theory. He reviews critically the views of other writers, and argues strongly in favor of magmatic solidification, holding that it affords satisfactory explanations of the chief facts of composition, texture, structure, and relations to the inclosing formations.

That water plays a more or less essential part in the formation of igneous magmas, at least those of acid character, is now so generally conceded that it would be idle to advance arguments against the view that pegmatite is the product of dry fusion. In fact it would probably be difficult to prove that any of the so-called igneous rocks, have resulted from strictly anhydrous processes. The real question is, then, can acid pegmatites be regarded as the direct product of such a slightly aqueo-igneous fusion or magma as yields the normal granites? It appears to the writers that a sufficient answer to this question is to be found in the characters of granite—a fine and even-grained rock of remarkably uniform composition and devoid of pockets. This absolute lack of agreement in the fundamental characters seems to render a more detailed comparison superfluous. It is thus obvious that the igneous theory also, although accounting satisfactorily for the order of crystallization in pegmatite, broken crystals of tourmaline and beryl, parallel orientation of inclusions, etc., requires important modification, and especially a larger intervention of water; for it does not appear that the variation of any other factor, such as pressure or temperature, would meet the necessities of the case.

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*Lehrbuch der Geognosie, 2d Ed., 2, 232 (1858).

Brögger, however, among recent writers, seems disposed to minimize the influence of water: and in the differentiation of pegmatite from normal granite to allow it practically no part whatever. He says* "the principal requirement for the solidification of deep-seated magmas to holocrystalline plutonic rocks, seems, therefore, to consist in a sufficiently slow cooling of the water-bearing magma, under a pressure of superimposed matter great enough to prevent the water separated out by crystallization from freely escaping to the surface, and compelling it by a pressure exerted from above to pass into the wall-rock (contact metamorphism)." Although so clearly recognizing the presence of water, and using it to account for certain contact phenomena, he does not, apparently, regard it as in any way essential to magmatic differentiation, either chemical or textural, but treats the magma, virtually, as if it were anhydrous throughout its entire history; and yet he repeatedly invokes the aid of certain "agents mineralisateurs," which are nowhere more explicitly designated or described. His non-utilization of the water in the magma obliges him to refer the gigantic crystallization and irregular composition so characteristic of pegmatite wholly to the slowness with which it has cooled and solidified. He says† "both when they (the pegmatites) occur in the main mass of the allied eruptive rock (parent plutonic), and when they occur in the neighborhood—and one of the two is always the case—we may assume that the rock surrounding the vein-stone (pegmatite) was first heated to a high temperature and that, therefore, the cooling must have taken place unusually slowly and uniformly; and upon this fact primarily the largeness of the grains may be explained."

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*L. c., 45.

†L. c., 67.

This explanation of these extremely important characters, which no theory of pegmatite can ignore, appears to us singularly inadequate, in view of the following considerations: (1) The surrounding rocks must always be cooler than the great body of granitic magma by which they are heated. (2) The coarsest pegmatite is often in narrow dikes thousands of feet if not miles distant from the border of the plutonic mass in which it originated. (3) If, as Brögger insists and we believe, pegmatite is the end-product or final crystallization of the original granite magma, we are, to paraphrase his criticism of Lehmann, (p. 43) led to the remarkable result that a body of magma solidifying as the result of cooling has a higher temperature and therefore crystallizes more slowly and coarsely in the later than in the earlier stages of the process. (4) Brögger holds that the most typical pegmatite may be, and in special instances cited by him must have been, formed at very moderate depths below the earth's surface—a few hundred feet to two or three thousand feet. How, under these conditions, the vast body of granite magma at greater depths and cooling far more slowly escaped conversion into pegmatite is a mystery which he nowhere offers to explain.

But he goes on to say* "That this explanation of the coarse grain and of the imperfect zonal structure of many pegmatite veins is correct, is rendered probable in the highest degree by the frequent occurrence of pegmatite structure in those portions of rock bordering on the open drusy cavities of many massive granites. I interpret these as analogous to the formation of the pegmatite veins themselves, in the following way: First, on account of the contraction due to crystallization of the rock already for the most part solidified, there were formed crystal-free *lumina* (microlitic structure on a large scale): the mixture of magma and crystals so formed, which must have constituted a somewhat solid rock, inclosing the lumina, was, however, completely permeated by the magma, and with this these crystal-free spaces would naturally have been filled. By continual cooling, this magma, beginning at the walls, also crystallized out slowly and uninterruptedly, often mixed with minerals which had been formed by special 'agents mineralisateurs'; the conditions of such crystallization, proceeding from the walls of the *lumina* inwards, must have been somewhat different from those of the former crystallization, which took place within the mass of the whole solidifying rock-matter, where the separate individuals must have crowded upon one another, etc.; hence the ever increasing size of grain, the zonal structure (conditioned by the crystallization from the walls inward), etc. If the magmatic silicate solution were not concentrated to such an extent that the *lumina* were completely filled by its crystallization, first, open drusy cavities must have resulted, which finally through continued circulation might be filled in with minerals deposited from solutions at first still hot but later less and less hot. The filling up of the drusy cavities corresponds according to this interpretation pretty exactly to the complete vein formation of the pegmatite veins which occur outside the normal-grained rock mass; the explanation throws light in both cases upon the continuous transition from the rock formed purely by magmatic solidification to the final minerals of the druses deposited from solutions not exactly magmatic (less concentrated)."

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*L. c., 67.

This statement certainly leaves much to be desired in the way of clearness, and we confess ourselves unable to gather from it with certainty the author's meaning. Considered simply as a suggestion or outline of the mode of formation of pockets, we should not care to criticise it. The references to more and less concentrated magmatic silicate solutions suggest the possible intervention or agency of water; but in view of the facts that this is not explicitly stated and that anhydrous magmas are now generally regarded as true solutions, the idea of minimizing the aqueous influence is obvious. Whether Brögger should really be classed with the advocates of the igneous or the aqueo-igneous theory of pegmatite is, therefore, doubtful: and it has seemed best to us not to hazard a guess as to the possible hidden meaning of his language.

AQUEO-IGNEOUS THEORY.

Although the igneous theory, even in its more modern forms, so obviously fails as a complete explanation of pegmatite, yet it is distinctly along this line, from Charpentier's view as a starting point, that we have advanced to the conception of a more perfect cöoperation of heat and water. Referring to Williams' summary* of pegmatite theories, we learn that Élie de Beaumont in his famous essay "Sur les emanations volcaniques et métalliferes,"† while accepting in the main the igneous and intrusive origin of pegmatites, introduced an important addition in assuming water and other mineralizing agents as necessary factors in their formation. Scheerer,‡ in a contemporary paper, attributed a still more important role to water in the formation of pegmatites, holding what Hunt§ has designated as the theory of "granitic juice," a highly heated aqueous solution of mineral substances impregnating the congealing mass and oozing out under pressure into the surrounding rocks. Lehmann,‖ in his large and excellent work upon "The Granulite District of Saxony," as quoted by Brögger, endeavors to account for the pegmatite veins of that region. He assumes the aqueo-igneous (hydatopyrogene) formation of granite, and pronounces the veins in a sense to be injection veins. "The granitic veins of the granulite district have originated, no doubt, with the aid of more or less water, but this has not been atmospheric water which has percolated downward through the cracks of the granite, but it is eruptive water, which was given up from the granite to the surrounding rocks, and which, under peculiar conditions obtaining at great depths, was supersaturated with mineral matter." Lehmann assumes for the granitic magma a gelatinous consistency, which was to be accounted for, presumably, by the presence of "viscous silicic acid." "These fluid secretions of granite may be compared to hot jelly." * * * * "The capacity of silica to form jellies with much or little water invites strongly to this hypothesis." "Between such a gelatinous magma and a saturated aqueous solution a large number of consecutive intermediate stages can be imagined. In this way, it seems to me, the connection between the pegmatitic veins and the ordinary granites, the remarkable segregations in the shape

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*U. S. Geol. Survey, Annual Report, 15, 676.
†Bull. Soc. Géol. Fr. (II), 4, 12 (1847).
‡Bull. Soc. Géol. Fr. (II); 4, 468.
§Chem. and Geol. Essays, 189 (1775).
‖Granulitgebirge, 52-58.

of pegmatitic veins opening out into druses, and finally the connection of these with vein-fillings which consist only of quartz, tourmaline and potash mica, or of quartz alone, can be explained, etc." Lehmann still farther emphasizes the role which water plays in the magma in holding that a high temperature is unnecessary to its formation and evolution. The increasing agency of water brings us next to Reyer,* who regarded the pegmatites as excretions of the solidifying magma, representing the last stage of solidification where water was largely active, while Keilhau, Hausmann, and Daubrée regarded the pegmatites as mainly aqueous deposits, but genetically connected with granitic intrusions.

Notwithstanding his belief in the igneous origin of pegmatites in general, Brögger accepts the aqueo-igneous theory for a not insignificant proportion of them. He says† the pegmatites, although chiefly magmatically solidified veins, pass into the crack-fillings which succeed them in point of time and which are not in the main, or are not at all, deposited from true magmatic solutions. To this he adds in a footnote, "Many large-grained veins of a pegmatitic structure have been formed principally by pneumatolitic (aqueo-igneous) processes, and not mainly by magmatic solidification," citing as examples the apatite-bearing basic veins and many occurrences of cassiterite, tourmaline, topaz, etc. Also that the muscovite granite pegmatite veins, containing especially beryl, topaz, etc., and having as principal minerals microcline, oligoclase, albite, quartz, muscovite, are, in comparison with the ordinary granite pegmatite veins with which they frequently occur, of somewhat later formation, a slightly different magma, and to a larger extent of pneumatolitic formation.

This review of opinion shows that while several previous writers have recognized the important and necessary agency of water in the formation of pegmatite, varying between heat as the chief agent with water coöperating (igneous processes), and water as the chief agent with heat coöperating (aqueous processes), Lehmann alone has given us a complete statement of the aqueo-igneous theory, or recognized the essential continuity of the igneous and aqueous processes and the consequent complete blending of fusion and solution, and their products—the igneous and aqueous rocks. The present paper may be regarded, therefore, as based upon Lehmann's work—a restatement of his views, with more complete elaboration and illustration in certain directions.

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*Theoretische Geologie, 101 (1888).

†Canadian Record of Science, 6, 69.

All lavas appear to be more or less hydrated at the time of their extrusion; and, however much opinions may differ concerning the source of the water and its original relations to the magma, it is generally conceded that at the moment of eruption they are very intimately united, and that the former increases the liquidity and the eruptive energy of the latter. Water is very thoroughly diffused through the earth's crust; and it has probably penetrated to so great a depth as to warrant the conclusion that all the so-called igneous rocks now exposed to our observation are in some degree the products of aqueo-igneous fusion. It is unnecessary,however,to insist upon this broad generalization, for, although it may be questioned for some of the plutonic rocks, it is very generally conceded to be true for those with which we now have to do—the acid plutonics or the granites.

The order of crystallization of the component minerals, and the fact that the quartz, which has been in every instance the last mineral to crystallize, is usually crowded with aqueous inclusions, leave no room to doubt that water was present and played an important part in the formation of granite. It is quite unnecessary to raise here the question as to whether or not the granites are metamorphosed sediments; for those who would answer in the negative must, apparently, concede that there is a hydrated zone of the primitive igneous crust beneath the oldest sediments. In fact, the hydration of the original or still unstratified igneous crust to a great depth below the oldest sedimentary rocks appears to the writers a peculiarly safe assumption, for we have to do here with a portion of the primitive crust which formed the immediate floor of the primitive ocean.

Assuming, then, without farther argument, that the granites have been formed in the presence of water, it may be noted that the number, minuteness, and universal presence of the liquid inclusions indicate that, as in modern lavas, the water was very intimately combined with the granite magma.

As the magma cools, the various minerals develop and crystallize out in the general order of their basicity, each, in turn, excluding, so far as possible, the still unindividualized magma and water, just as any crystals formed in a solution exclude the solvent. The magma thus becomes steadily more and more acid and hydrated; and when, finally, the free silica alone remains unsolidified, it is probably combined with sufficient water to hold it temporarily in the gelatinous state. As this gelatinous silica slowly and spontaneously dehydrates and crystallizes it necessarily imprisons the main part at least of the water, which, like a true solvent, is the only part of the magma that remains permanently unsolidified.

Conceive, now, that a large boss or massif of molten granite has invaded the crystalline schists at a great depth and is undergoing extremely slow refrigeration. Crystallization begins on the surface of the mass and gradually extends inward. The rate of cooling diminishes as the crust thickens, but the highly viscous nature of the cooling magma prevents the formation of large crystals. Finally, however, as the outer shell of the boss becomes gradually thicker, the rate of cooling and crystallization are sufficiently reduced to enable the quartz, as it slowly hardens, to exclude a portion of its inclosed water, forcing it inward into the still liquid magma; which is thus rendered more liquid, but not sensibly so at first, for the slowness of the process permits the diffusion of the excluded water through a large volume of unconsolidated magma. The extremely gradual nature of the changes is an essential feature of the explanation. The feldspar and mica probably crystallize in part at least, far in advance of the quartz, forming a reticulated or sponge-like zone, through the meshes of which the silica gradually expels a portion of its water. This process is, perhaps, favored by the tendency, through contraction, to reduce the pressure in the interior of the mass. The magma thus becomes, although its temperature is slowly falling, more and more liquid, passing gradually from the condition of aqueo-igneous fusion to that of igneo-aqueous solution; and the greater mobility of the latter state permits the formation of larger crystals. We may thus conceive a perfect blending of the conditions favoring the formation of normal granite in the exterior portion of the mass with those favoring the formation of giant granite or pegmatite in the central portion.

Cooling, crystallization and dehydration are processes involving contraction, and thus, as in a septarian concretion, there is a manifest tendency to form vacant spaces or cracks in the interior of the boss, in which the highly hydrated and liquid residuum of the magma collects and slowly crystallizes. If these cracks extend through the hard crust of the boss into the surrounding or overlying schists, or if fissures due to extraneous causes penetrate the boss, they will become the seats of sharply outlined and typical veins of pegmatite.

The gradual character of every phase in the refrigeration and solidification of the boss makes it absolutely necessary to suppose that there must be somewhere a perfect gradation from the normal granite to the coarsest pegmatite. As previously stated, this gradation may be observed to some extent in the natural ledges; but we may fairly suppose that, while the cooling of the boss would be partly lateral, it would take place mainly downwards; and since distinct veins of pegmatite represent an actual extravasation of the aqueo-igneous magma, it is apparent that the gradation in question should be sought mainly in depth. It appears to us probable that some of the coarser plutonic rocks, like the syenite of Marblehead, Mass., in a portion of which the crystals of feldspar are from four to six inches in length, should be regarded as intermediate between those of the more normal texture and pegmatite.

It is, perhaps, not impossible that a portion of the water required for the more perfect hydration and liquefaction of the residuum of the magma may be derived from extraneous sources. The boss is a great body of magma which has been forced up to, or developed in, a position of the earth's crust far above its normal level. It brings the deep-seated temperature and other conditions up into the region of comparatively active aqueous circulation; and it may be that shrinkage cracks or faults, if not interstitial percolation in accordance with Daubrée's law, would admit meteoric or relatively superficial waters to a participation in the differentiation of the magma.

There appears to be an opportunity presented, also, to apply Soret's principle, upon which Iddings so largely relies, in his valuable essay on the origin of igneous rocks*, as a cause of the differentiation of purely igneous magmas. Soret demonstrated that if two parts of a solution of any salt be kept at different temperatures there will be a concentration of the salt in the cooler part of the solution. Iddings holds that in any molten magma certain oxides play the role of solvents for the others. But if Soret's principle admits of application to an anhydrous magma, much more should it be applicable to a magma in a state of aqueo-igneous fusion. In the granite boss the cooler part is the exterior, and toward the exterior, therefore, the dissolved bases will be concentrated, leaving in the interior a more highly hydrated portion, which will be in a state of igneo-aqueous fusion, and from which may be developed the coarse crystallization, comb-structure, and pockets of typical pegmatite. This principle probably coöperates with and is, perhaps, intrinsically more important than that of the exclusion of water by crystallization. The main point of this paper is the explanation of the pegmatites through a differentiation of acid magmas in which water plays an important part, the differentiation involving for the magma residuum a transition from aqueo-igneous fusion to igneo-aqueous solution. The possible intervention of extraneous water has been suggested, but this is not deemed essential.

The increase in the degree of hydration of a small part of the magma, through the exclusion of water during solidification by the remainder, is substantially the explanation which Iddings offers for the phenomena presented by spheratites and lithophysæ. A moderate increase in the proportion of water about centers, the proximity of which will be determined by the viscosity of the magma and the rate of cooling and solidification, gives the unsolidified residuum sufficient liquidity to permit the incipient radial crystallization of the spherulite; while a higher degree of local hydration gives rise to the concentric crystalline shells and shrinkage cracks (pockets) with the highly perfect crystallizations of feldspar, quartz, fayalite, etc., characteristic of the typical lithophysæ.

An analogy may also be traced between this illustration of pegmatite and what appears to us to be the best explanation of the quartz geodes in certain limestone formations. Soluble organic silica originally disseminated through the limestone is dissolved by percolating water and subsequently replaces the calcium carbonate of the limestones about favorable centers. The silica is precipitated and accumulates in a highly hydrated and gelatinous form. Its volume is thus sufficient to fill the globular cavity due to the solution of the limestone; and, theoretically, the accumulation continues until the soluble silica in the tributary portion of the limestone is exhausted. The gelatinous silica then slowly dehydrates and solidifies. This process begins at the surface; a continuous and impervious shell is thus formed; and the remaining silica slowly adds itself to the inner surface of the shell. The viscous nature of the hydrate does not allow the molecules of silica sufficient freedom of movement for the development of a visibly granular or crystalline structure; and the outer layer of the shell is, therefore, cryptocrystalline or chalcedonic. But a process of spontaneous differentiation is in progress. The separation of a portion of the silica renders the solution more mobile, the molecules move more freely, so that cryptocrystallization usually gives way to phenocrystallization, and the inner surface of the geode is studded with large and perfect crystals of quartz. The finely crystalline normal granite forming the main part of a boss corresponds to the chalcedonic shell of a geode, and the central veins and masses of pegmatite to the crystalline lining. The much larger proportion of water in the ball of colloid silica from which a geode is evolved determines a greater preponderance of the coarser crystallization and a relatively larger central cavity or pocket than in the granite boss; while the vastly slower crystallization of the boss prevents, as a rule, even the outer part from being left in the semi-amorphous or felsitic condition, which would be essential to give a perfect correspondence with the chalcedonic outer shell of the geode.

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*Bulletin of the Philosophical Society of Washington, 12, 158.

We have observed in New Hampshire, as Williams has in Maryland, and other writers in Europe, a perfect gradation in composition between veins of typical pegmatite and ordinary quartz veins. The quartz veins often intersect the pegmatite and are obviously newer; though it is probable that they are usually substantially contemporaneous with the great masses of quartz which are such a characteristic, as well as the latest, feature of the pegmatite. We hold. with Lehmann, that the most satisfactory explanation of this blending of pegmatite with quartz veins on the one hand, as with normal granite on the other, is to be found in a corresponding blending of aqueo-igneous fusion with igneo-aqueous solution; and this dynamic gradation, it appears to us, can only result from the gradual hydration of the residual magma during the slow centripetal solidification of a body of magma and a consequent elimination of water.

In any case, the solidification and crystallization of a body of magma must be conceived as centripetal; and this consideration makes it impossible for us to agree with Brögger that the water of any considerable volume of magma would pass outward through the constantly thickening shell of granite into the wall-rock. And before the solidification begins the diffusion of magmatic water through the wall-rock appears equally improbable, since the magma is to be regarded as a chemical union of water and fused rock, a true hydrate, which is dissociated by crystallization, but while actively molten under pressure,absorbing water rather than giving it off. Furthermore, it appears to us probable, or at least possible, that magma injected into the wall-rock may become more liquid, in spite of cooling, through absorption of water; provided the wall-rock has a high temperature, or the magma is already sufficiently hydrated to have a low fusing point. Local absorption of water from the wall-rock would best account for the pegmatitic character of the small dikelets or apophyses of granite, to be observed on the shores of Marblehead and Swampscott, Mass. The main body of granite is quite free from pegmatitic characters; but the innumerable branches or apophyses of granite ramifying through the bordering diorite are very generally pegmatitic, at least in part, with frequent gradations, the most typical pegmatite passing by insensible steps into the normal granite on the one hand and ordinary vein quartz on the other. The dikelets vary in size from half an inch or less to several feet in width, even the smallest often exhibiting perfectly the gradation just noted; and the pegmatitic character is quite commonly accompanied by a more or less distinct banding or zonal structure—symmetrical bands of feldspar (red orthoclase) on either wall, with quartz and sometimes epidote and allanite in the middle. Long, narrow pockets are a very characteristic feature of these banded veinlets of pegmatite, indicating a high degree of hydration of the magma.

Although the fluidity of the highly hydrated pegmatite magma would make extravasation easy, and thus, perhaps, readily account for the size and number of the pegmatite veins in the surrounding formations, and the fact that they sometimes extend to great distances from the parent plutonic mass; yet extravasation of a definite pegmatite magma is out of the question in the Marblehead and Swampscott occurrences, and the pegmatite must be due essentially to a differentiation *in situ* of the normal granite magma, the only cause of the differentiation which we are able to recognize being the absorption of water from the wall-rock. While studying the pegmatites of New Hampshire we were strongly impressed as already noted, by the number, size and general prominence of the pegnatitic veins in the schists, even at considerable distances from the mother rock—the Concord granite, the pegmatite being quite in contrast, in this respect, with the normal granite, which seems to form but few apophyses or dikes in the schists. In fact, we believe it may be truly said that while pegmatite intrusions are especially characteristic of the schists, intrusions of the normal Concord granite occur chiefly in the more massive formations (Winnepesaukee gneiss, porphyrytic granite, etc.). These considerations have recently suggested to us the following modification or extension of the pegmatite theory:

Pegmatite magma may be formed in two distinct ways: First, by normal magmatic differentiation in a boss or large body of magma, both crystallization and the operation of Soret's principle tending, as already explained, to increase the degree of hydration of the magma residuum about favorable centers. These magma residues may crystallize *in situ* in the midst of the previously solidified normal granite, giving rise to what may be called sedentary pegmatite, which is especially characterized by its gradual passage outward into the normal granite; or the pegmatite magma may suffer extravasation, finally crystallizing in spaces of discission or dissolution in the parent plutonic, or in the surrounding formations. Second, apophyses of the normal granite magma may invade highly heated, water-bearing formations, such as the schists, and experience the necessary hydration for conversion into pegmatite magma through the absorption of this extraneous water. The high temperature of the wall-rock is essential, as previously noted, to prevent the chilling and crystallization of the magma before the absorption of water can take place.

It cannot be argued that this principle would lead to a peripheral development of pegmatite in the main bodies of granite, for while the volume of water-bearing wall-rock per unit of surface of the body of magma would not be increased, the volume of magma through which the water would be diffused as fast as absorbed would be enormously greater and no exceptional or marked degree of hydration could result. That the wall-rock must have been highly heated, contrary to Lehmann's view, is reasonably certain from the absence in both the granites and pegmatite of the normal gradation in texture due to the chilling action of the walls. On the other hand, this high temperature probably would not tend to expel the water from the inclosing formations, and thus prevent them from contributing water to the invading magmas; for the well-known experiments of Daubrée and Poiseuille indicate that within certain limits, at least, the heat favors rather than hinders the downward progress of the water in the earth's crust; and it appears to us very probable that the absorption of water by deep-seated magmas is another cause operating to the same end. It can hardly be doubted that the temperature was well above the critical point for water, and hence the hydration of the magma really means the absorption of superheated aqueous vapor under enormous pressure. This extension of the pegmatite theory overcomes the obvious difficulty as to the extensive extravasation of pegmatite magma evolved or originating deep down in a great boss of solidified granite; and apophyses of normal granite accompanying pegmatite may reasonably be referred to a somewhat earlier period, when the thermal conditions were still unfavorable to aqueous absorption.

Pegmatite magma may not only be assumed to be more liquid than that of normal granite, but to solidify less promptly, solidification being due only in part to cooling and in part to spontaneous dehydration,—a general principle, the application of which to the pegmatite magma is indicated by the absence of hydrous species among the component minerals. The experiments of Daubrée and and others favor the view that the proportion of water essential to the constitution of the pegmatite magma is small; and this is indicated, also, by the infrequent and relatively small pockets; although the enormous pressure prevailing at these great depths may, perhaps, tend to prevent the formation of pockets.

The origin of pegmatites at great depths is suggested by the regional metamorphism of the schists and the consequent general absence of characteristic or significant igneous contact phenomena; and a high temperature may be inferred from the usually jagged outlines of the veins, indicating a tearing or rending, rather than a breaking, of the rocks, as if they had been softened and toughened by heat. The minute, thread-like veins and apophyses, both of pegmatite and common granite, and the very common lack of gradation along the walls for both rocks, and other facts point to the same general conclusions. The pegmatite magma is probably very liquid only in pockets; while for the development of the normal pegmatite a much thicker jelly than the normal granite magma, combined, as in the latter. with extremely slow cooling and dehydration, seems to be required. The order of crystallization shows that pegmatite magma is only a more extreme form of the granite magma. In a true igneous or granite magma, however, the size of the crystals is definitely limited by the viscosity; and beyond a certain point it is practically independent of slowness or rate of cooling. It may be noted, also, that while in pegmatite the tabular and prismatic crystals tend to be perpendicular to the walls, in true magmatic consolidation the orientation of the crystals is essentially indifferent to the walls.

The essential continuity of fusion and aqueous solution is not readily demonstrated by experiment. Under the relatively moderate pressures which have been employed, the addition of heat to a solution, beyond a certain low maximum, vaporizes and expels the solvent; and, in like manner, although the addition of water to a magma promotes liquidity, the amount of water which the magma can retain is insufficient to offset the loss of heat due to the vaporization of water. It is clear, however, that with increased pressure solutions might be hotter and fusions more highly hydrated; and we see no reason to doubt that at moderate depths in the earth heat and water may exist in equal and perfect coöperation. Whether at greater depths igneous fusion prevails must depend, of course, upon the temperature and its relations to the elevation of the fusing point by increase of pressure. The absorption of water under pressure by a liquid magma appears to be a chemical process, a true hydration, the water disappearing as such. If this view be correct, there is certainly some reason to think that we have here a reinforcement of Daubrée's explanation of the downward progress of water in the earth's crust. It is not only urged down by capillary attraction, but also, as previously stated, to make good the loss due to its absorption by deep-seated magmas.

Pressure promotes aqueous absorption and solution, but retards fusion by raising the fusing point. High temperatures, on the other hand, favor fusion, of course, but are antagonistic to aqueous absorption, and hence to solution. If, as we must believe, the pressure increases more rapidly at great depths than the temperature, it may well be as has been clearly shown by others, that purely igneous fusion nowhere obtains, but the molten magmas at the greatest as well as at moderate depths are in a state of aqueo-igneous fusion. It is a necessary corollary to this view that as refrigeration progresses and water is, in consequence, more abundantly absorbed, the degree of liquefaction at a given depth increases until heat and water are in perfect coöperation, and then declines with farther loss of heat, since it is manifestly impossible that sufficient water should be absorbed at any depth to give a general liquid zone by approximately pure solution. It is probable, therefore, that the continuity of fusion and solution is most fully realized during the differential solidification of a body of magma; and pegmatite is, in a truer sense than any other lithologic type, the connecting link between igneous and aqueous rocks.

Strictly speaking, nearly all, if not quite all, known rocks are secondary. This is generally conceded for the sedimentary rocks; but, following Iddings and other recent writers, it must be admitted also for the igneous rocks. A dike is a more or less highly differentiated portion of some deep-seated magma, and it is clearly newer than the walls. An ascensionist, certainly, can say nothing more for a vein, save that while in the formation of the dike heat is the chief agent with water coöperating (aqueo-igneous fusion), in the formation of the vein water is the chief agent with heat coöperating (igneo-aqueous solution). The greater mobility of the solution permits a higher degree of concentration; but concentration is a universal process and participates in the formation of eruptive masses and sedimentary deposits as well as of veins.

In the opinion of the writers, no sharp line of demarcation can be drawn between dikes and veins, and veins are clearly entitled to some degree of recognition in the lithological classification. In a broad view of the early history of the earth, all the sedimentary and vein rocks are, of course, secondary with reference to the primitive igneous crust, but so are the igneous rocks with which we are now acquainted. Probably none of the igneous rocks which have been studied are truly primitive, and their derivation in some cases from sediments is claimed by many able observers.

Heat and water are the two great agents concerned in the modification and differentiation of the earth's crust; and they are generally, if not everywhere and always, in coöperation, heat prevailing, as a rule, at great depths, and water at the surface. Thus arise the two principal classes of rocks—igneous and aqueous. In either class the rocks may be deep-seated (newer than both walls) or superficial (newer than one wall), in other words, intrusive or contemporaneous. The intrusive igneous masses are known as dikes, etc., and the contemporaneous as lava-flows; while the intrusive aqueous masses are known as veins, etc., and the contemporaneous as sedimentary strata. Between the vein rocks and dike or plutonic rocks we have, at great depths, a perfect transition, in the pegmatites; but between volcanic rocks and sediments transition forms are wanting, because the limited pressure does not permit the coöperation of heat and water.

Since this paper was written, the *16th Annual Report of the United States Geological Survey* has appeared, containing Van Hise's important discussion of the principles of Pre-Cambrian geology. We are pleased to see (p. 687) that he holds very strongly to the essential continuity of fusion and solution at great depths in the earth, and finds in this coöperation of aqueous and igneous agencies the best explanation of the main part at least of the pegmatites, although holding with Brögger that they are, in part, of normal igneous origin.

THE GALENA AND MAQUOKETA SERIES.

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Part IV.

In parts one and two of this paper a revision of the Galena and Maquoketa series has been discussed and a classification has been outlined in emended form. The two series are divided primarily into fourteen beds and secondarily into five formations each of which includes one or more of the beds. In order to illustrate more fully the paleontological evidence upon which the classification is largely based, parts three and four of the paper are devoted to the discussion of that subject. Part three is a digression comprising a paleontological study of the very important Galena (Trenton) and Maquoketa (Hudson) fossils known collectively as *Orthis testudinaria* Dal. Two similar groups will be added here in order that they may be united in the subsequent discussion, but it will not be necessary for the present, to enter so fully into the paleontological discription of these as of that one. Such wide digressions if repeated might result in making the major title of my paper non-representative of its major content, and cause the final and premeditated discussion to be crowded into a mere footnote. The discussion of *Orthis testudinaria* itself in part three is taken from a larger unpublished work of mine, and adapted to the present needs because it represents one of the most necessary stages of paleontologico-geological study of the Galena and Maquoketa series. The same spirit is intended to pervade the study of *O. testudinaria* and the two other groups of related Brachiopoda that are chosen for comparison with it, and it will be sufficient to give the general results only of the investigation of the other two. After briefly reviewing them, a comparison of the same will be given in as far as they aid in determining the true relations and the relative time interval of the beds and formations of the Galena and Maquoketa series.

ORTHIS TESTUDINARIA.

Orthis testudinaria auct. was found in part three of this paper to comprise several distinct species or varieties in the Ordovician. There is one of these viz. *O. rogota* Sar. in the Galena series ranging from the top of the Stictopora bed (number 4 in ascending series) to the Lingulelasma bed (8). Of the Maquoketa species *O. corpulenta* Sar. is found in the Triplecia bed (10) and the Leptæna bed (13), *O. ignota* Sar, is found in the Leptæna bed (13) only, so far as known; *O. tersa* Sar. belongs to the same or little later horrizon; *Orthis emacerata* Hall ranges through three beds (12 to 14),*O.porrecta* Sar. belongs to the Triplecia bed (10) but is found as a secondarily deposited fossil in part of bed number 11 also, and *O. futilis* is known from beds number 10, and 13. Evidently, *O. emacerata* Hall is not only contemporaneous but also of earlier occurrence in the lower beds at Cincinnati, Ohio, and in the Trenton Falls, N. York, series, while *O. corpulenta* would seem to be early represented at the latter locality.

PLECTAMBONITES.

Species of the genus *Plectambonites* in the Galena and Maquoketa series occur in geologic succession in the strata, but they do not form a corresponding morphologic series. Of the several forms that together comprise the *Leptæna* (*Plectambonites*) *sericea* auct., of this region, no two occur in the same bed, but one of them is associated with *P. gibbosa* W. and S. *P. gibbosa* is not widely distributed, is narrow in range vertically, and it has no varieties. *P. sericea* Sow., as usually defined, is, on the contrary, one of the most widely distributed of Ordovician brachiopoda here as in other parts of North America and in Europe, but it has several "varieties," at least five in this region, and these are each less widely found and are all of more limited range, like *P. gibbosa* W. and S. It is not known how many kinds there are in the world, nor whether any of ours are found in Europe, but it is evident that several kinds are found there, and the same varieties may occur on both continents. The following are the species from the Galena and Maquoketa series:

1. *Plectambonites sericea* (Sowerby). Siluria, pl. 19, f. 1, (1839); Davidson, Silurian Brachiopoda, p. 323, pl. 48, fig. 10-19, (1871), is probably the same as the first of our forms in the Galena series. It has been so identified by Hall, Pal. N.Y., vol. 8, pt. 1, pl. 15, f. 25-29, (1894); vol. 1, p. 110, pl. 31, B. f. 2 (1847), although the figures by the English authors represent the dorsal muscle scars differently from our specimens. This species is found in the Stictoporella bed (3) and in the top of the Stictopora bed (4), and abundantly in the Fucoid bed (5) of the Galena series.

2. *P. minnesotensis* (Sardeson). Bull. Minn. Acad. Nat. Sci., vol. 3, p. 329, pl. 6, fig. 24-25 (1892), is very abundant in the Orthisina bed (6), rarer in the Camarella bed (7).

3. *P. gibbosa* Winchell and Schuchert, final rep., vol. 3, Geol. Nat. Hist. Sur. Minnesota, p. 416, pl. 32, f. 13-17 (1893) is known from the Lingulelasma bed (8), in Minnesota only.

4. *Plectambonites* cf. *sericea*. A few ventral valves of a large species are associated with the last in the upper part of the bed, in Dodge county, Minnesota.

5. *P. præcosis* (Sardeson), loc. cit., p. 329, pl. 4, f. 26-28, is abundant in the Triplicia bed (10) of the Maquoketa series.

6. *P. saxea* (Sardeson), loc., cit., p. 330, pl. 4, f. 33-35, is known in Minnesota and Iowa in the Orthoceras bed (12).

P. recedens (Sardeson) loc. cit, p. 330, pl. 4, f. 29-32 (1892). *P. sericea* W. and S., (non Sow. ?) loc. cit., p. 414, pl. 32, fig. 12, 10-11, (1893); *Leptæna sericea ?* Meek, Pal. Ohio, vol. 1, p. 70, pl. 5, fig. 3 a-e, not f-h, (1873), is common in the Leptæna bed (13), and Orthis bed (14), of the Maquoketa series, and is the same, apparently, as found in the upper part of the Cincinnati shales in Ohio.

These species follow closely upon one another in the strata, and if phylogenetically successive varieties of the same species be interpreted from their relationships, it remains, nevertheless, evident that the transitions are wanting, as in *Orthis testudinaria* auct. In the lower Cincinnati shales of Ohio there is still another species, *Plectambonites aspera* (James) Cincinnati Q. J. Sci., vol. 1, p. 151 (1874); *Leptæna sericea*

Meek, Pal. Ohio, vol. 1, p. 72, pl. 5. fig. 3, f-h, (1873,) which occurs at 150 feet above low water line of the Ohio river at Covington, Kentucky, and this one is there the predecessor, possibly the ancestral form of *P. recedens* (Sar). It would, however, very much raise our confidence in such a theory of derivation, if, in any one case, these species or varieties and forms, as they have been called, had been traced by intermediate steps from one to the other.

The evolutionary changes took place in one of two ways, either quickly in a few obscure individuals, or gradually in perhaps many. In the latter case it is necessary to assume either that great time intervals are represented between certain beds, or that the evolution took place in other regions, the "varieties" migrating sucessively into this area. If the evolutionary changes were sudden, the several species are certainly "distinct," but if gradually then, too, they are distinct so far as is yet known. It is highly improbable that the differences between these species are due to evolution in this area during time intervals, i. e., no such time intervals can be supposed in accord with the known facts.

It would be easy to confuse one of the above species with another if not kept separate by the collector, because the external characters are combined with many extreme differences due to accident of growth, and because the interiors are not only very liable to changes through maceration, but also the differences between a young mature shell and a senile one of the same species are more striking than the specific differences, between two of different species.

One or two distinguishing features may be given here. *Plectambonites sericea* and *P. minnesotensis* have the striæ less divergent from the margins of the cardinal areas, and the process between the two muscle scars on each half of the dorsal valve is relatively very small even in senile shells, as compared to the Maquoketa species. *P. sericea* is larger and correspondingly more coarsely plicated and much less convex on an average than *P. minnesotensis* is. Of the others, *P. recedens* is the synthetic type, is moderately convex and is about as large as *P. sericea* although more convex. *P. saxea* is large, very moderately convex and thin, *P. præcosis* is very convex, with heavy hinge area, and is small, *P. aspera* of Cincinnati, is convex and very wide in proportion to the shells length. *P. gibbosa* is outwardly like small *P. præcosis*, but is smaller, thicker proportionately, and generally triangular in outline.

RHYNCHONELLA.

The species of *Rhynchonella* that are found in the Galena and Maquoketa series had been practically all referred to one species by paleontologists, but have again been gradually separated more or less distinctly in the same manner as the group of *Orthis testudinaria* auct., described in part three of this paper, had been. These two groups of fossils are in fact similarly composed, both comprising several closely related species. In the *Orthis testudinaria* group however the Maquoketa species, as known, are the more numerous, while the *Rhynchonella* group has most representatives in the Galena series. It includes the following:—

1. *Rhynchonella minnesotensis* Sardeson, Bull. Minn. Acad. Nat. Sci., vol. 3, p. 333, pl. 4, f. 21-23, (1892). *Rhynchotrema inæquivalvis* W. & S. (partim) Final rep. Geol. Sur. Minnesota vol. 3, pt. 1, pl. 34, f. 9, 10, 15-23. (not 12-14): is found from the Buff limestone bed (1) to the Stictopora bed (4) in this area.

2. *Rhynchonella ainsliei* N. H. Winchell; 14th Ann. Rep. Geol. Sur. Minnesota, p. 315, pl. 2, f. 5, 6; *Rhynchotrema ainsliei* W. & S. Final rep. Geol. Sur. Minn. p. 459, pl. 34, f. 1-8, (1893) is from the Stictoporella bed (3).

3. *Rhynchonella increbescens* Hall (partim); Pal. N. York, vol. 1, p. 146, pl. 33, fig 13. a.-f. (1847). *Rhynchonella increbescens* Billings, Geol. Canada, p. 168, fig. 153(1863); *Trematospira quadruplicata* Miller, Cincinnati, Q. Jour. Sci., vol. 2, p. 60, f. 6-7 (1875); *Rhynchotrema inæquivalvis* W. & S. (partim), Final rep., Geo. Sur. Minnesota, vol. 3, pt. 1, p. 459, pl. 34, f. 12-14 only (1893).* This species is abundant in the Fucoid bed (5) gradually disappearing in the Camarella bed (8).

**Spirifer inæquivalvis* Castelman, is said by Winchell and Schuchert, loc. cit. to have the priority, and to be synonymous but they confuse two species and do not tell which is Castelnau's. *R. increbescens* Hall is only technically applicable to this species, *R. quadruplicata* is a preoccupied name, hence I have followed Billing's identification, *R. increbescens* Hall, Bill (1863).

4. *Rhynchonella* var. *laticostata* W. & S., *Rhynchotrema inæquivalvis* var. laticostata W. & S., loc. cit., fig. 26-29; *Rhynchonella sancta* Sardeson, Bull. Minn. Acad. Nat. Sci., vol. 3, p. 333, pl. 4, f. 19-20, is associated with *R. increbescens* H. in the Orthisina bed (6).

5. *Rhynchonella plena* (Hall), *Atrypa plena* Hall, Pal. N. York, vol. 1, p. 21, pl. 4 bis, f. 7 a-e (1847) is rare in the Fucoid bed (5) in Minnesota.

6. *Rhynchonella capax* (Conrad), *Atrypa capax* Con., Jour. Acad. Nat. Sci., Phila., vol. 8, p. 264, pl. 14, f. 21 (1842); *Rhychonella capax* Billings, Geol. Canada p. 211, f. 213 (1863): *R. capax* Whitf., Geol. Wisconsin, vol. 4, p. 263, pl. 12, f. 26-27 (1882); *Rhynchotrema capax* W. & S., Final rep. Geo. Sur. Minnesota, p. 462, pl. 34, f. 30-34, (1882), rare in the Lingulelasma bed (8) and the Triplecia bed (10) but common in the Leptæna and Orthis beds (13, 14). It is often compressed and is probably *R. perlamellosa* Whitf., in the upper Maquoketa.

7. *Rhynchonella anticostiensis* Billings, Pal. Foss., vol. 1 p. 142, f. 119 a-c, (1862); Winchell & Schuchert, Final rep. Geol. Sur. Minn., vol. 3, pt. 1, p. 464, f. 34 a-c (1893); found in the Orthis bed (14) in Iowa, Illinois and Wisconsin.

8. *Rhynchonella neenah* Whitfield, Geol. Wis., vol. 4, p. 265, pl. 12, f. 19-22 (1882); is said to be found with the last named in Wisconsin and Illinois.

10. *Rhynchonella perlamellosa* Whitf., loc. cit., p. 265, pl. 12, f. 23-25; is very similar to the *R. capax* (Con.), and is reported from the same horizon in Wisconsin.

The earliest of the above cited species is *R. minnesotensis* which in the Buff limestone bed (1) is found in schools filling whole laminæ, but the same are nearly all small, globose and resemble the figures of *R. orientalis* Billings, with which species they may be identical. Exceptionally a larger sized one is found that is a typical *R. minnesotensis* but the same is connected by every gradation to the smallest. Gradually the average size increases towards the top of the Stictopora bed (4) where the species disappears, but even there, although rarely, a specimen of the small form occurs. Typically the plications number about 20 on the ventral valve, of which three fall in the median sinus but often four or five rarely two or one, or six to eight instead of three obtain. The surface is nearly smooth. The associated *R. ainsliei* N. H. W. in the Stictoporella bed (3) is broader, finer plicated, and averages larger than *R. minnesotensis.* It has five to eight plications falling in the median sinus, but on the average there are six while *R. minnesotensis* has oftenest three or four. The two species are really entirely distinct, although no one known feature can be taken as an unfailing distinction.

In the Fucoid bed (5) are found a few *Rhynchonella plena* Hall—Chazy formation, of New York—and they are larger, proportionately longer, with less sharply defined median fold and sinus than the largest *R. minnesotensis*, but both have smooth surfaces and might if mixed together be wrongly referred to one variable species. Likewise *Rhynchonella increbescens* H. sensu stricto, which is found in beds Nos. 5 to 7, and taking the place of *R. minnesotensis*, not only can be but has been persistantly confused with the last named species. They are nearly alike in size, but *R. increbescens* has the shell smooth only up to a certain adult stage, then concentric, projecting, laminar structures or growth lines developed like those familiarly known on *Atrypa reticularis* L. although in this case never forming hollow spines on the plications. The median sinus embraces three, rarely two or four plications and of these the median one is not rarely largest. Measuring along the median line, the dorsal valve of *R. increbescens* is longer proportionately than that of *R. minnesotensis.* Acquaintance with both species makes their separation easy. *Rhynchonella* var. *laticostata* W. &. S. which is found in the *Orthisina bed* (6) associated with *R. increbescens*, is not found in all zones with the latter, but in one only, in the Galena series although its distribution is wide, being evidently represented in the Trenton of Kentucky and of New York. Its plications are strikingly broad, and large, and its surface is always smooth apparently because at the adult stage growth is arrested and senile walling up or dorso-ventral growth of shell at the anterior margin follows where in *R. increbescens* the fimbriated portion of shell growth begins. Winchell and Schuchert describe it as a variety understanding it to be not distinctly separable evidently and in this they are right, but whether it is an oft repeated sport, or a true variety, or a species that crossed with *R. increbescens*, or is merely confused because of its variations with the last named, I am not able to prove. The interior characters are unknown. *R. minnesotensis*, *R. increbescens* and *R. laticostata* appear to be all represented in the Trenton formation of New York and Kentucky. *Rhynchonella capax* Conrad succeeds *R. increbescens* but it is rare at first, and few specimens are known except in the upper Maquoketa. It is not evident however that the first are nearer to *R. increbescens* sensu stricto, in type than any others are, though both these species have elevated concentric, laminar growth lines. *R. perlamellosa* Whitf., has not been re-discovered, unless it is *R. capax* Con. *R. anticostiensis* Bill. has a straighter beak than *R. increbescens* Hall. *R. neenah* Whitf., is said to have a much deeper median sinus and a very prominent median plication. The three last named are from the top of the Maquoketa series. *R. dentata* Hall which has a single plication in the median sinus. is from the equivalent horizon in Ohio., there associated with *R. capax.*

CONCLUSION.

Winchell and Schuchert* are of the opinion that there can be little advantage to the geologist or the biologist in giving names to the "variations" of *Plectambonites sericea*, *Orthis testudinaria* and others of like character. Whitfield† and Meek‡ had expressed similar views, and all have considered the "varieties" as not distinct. I have endeavored to learn how far the same are distinct and distinguishable, and have become convinced that the different kinds are not united in the way that had been believed, in most cases. At all events, these "species" with their many "varieties," are our most abundant Ordovician fossils. and to slight them is equivalent to rejecting the more complete and detailed geologic and paleontologic evidence in favor of poorer, more isolated, though conveniently distinct data. I have not hesitated to give the "varieties" specific designations, because they are important and worthy of recognition, but I do not mean to say thereby that it would not have been useless for authors to give names

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*Final Rep. Geol. Sur. Minnesota. vol. III. p. 415.
†Geol. Wis., vol. IV. p. 258.
‡Pal. Ohio, vol. I, p. 109.

to "varieties" of *Orthis testudinaria* which they could not define, nor that the common excuse "we think the form in hand will prove to be a distinct species," whether written or reserved in the minds of authors, does not entirely negative the value of a new name. On the contrary, there seem to be many species with names to spare.

The paleontological work in this series of papers comprises too little to justify much discussion on classification of Brachiopoda. It may be said, however, that in the very promising materials examined, no case of the transition of one species or variety to another has been geologically traceable unless it be within *R. minnesotensis* Sar. from beds No. 1-4, or in. *R. increbescens* var. *laticostata* W. and S., but in most cases the biological relation remains doubtful except in so far as morphological similarity proves them to be closely allied species. Paleontologists do not hesitate to describe new species from a single specimen, or from many specimens from a single locality and horizon, and presumably there can be error in the definition of a species. It is desirable, of course, to have large collections in order to learn the variations and mutations, if any, but what is most distinctly noticeable in the Galena and Maquoketa faunas, described by authors, is that species have been described not only from insufficient materials, at times, but also from very abundant but poorly assorted collections. In a confused and badly collected set of fossils nothing is easier than to slight the truth, both in respect to the definition of the individual species and in respect to faunas.

In the groups of *Orthis testudinaria* auct. *Plectambonites sericea* auct. and *Rhynchonella increbescens* Hall (1847), one might have been led to expect abundant evidence of evolution from "variety" to "variety." Careful investigation, I think, proves that the evidence is from a biological source mainly, and that the addition of geological evidence necessitates new conclusions. The species ("varieties") succeed each other in a manner such as to prove their relation not to be that of "local varieties." They enter, as a rule, independently, quickly, and in the same order over the entire area, and thus they may be used to distinguish the different contemporaneous strata at distant localities. In the Buff limestone bed (1) the *Rhynchonella* cf. *orientalis* forms one distinguishing feature. In the Bellerophon bed (2) *R. minnesotensis* is more typical; in the Stictoporella bed (3) *R. minnesotensis* and *R. ainsliei* are associated with *Plectambonites sericea*, *sensu stricto*: in the Stictopora bed (4) *R. minnesotensis* is found; in the Fucoid bed (5) *R. increbescens*, *P. sericea*, and *O. rogata*; in the *Orthisina* bed (6) *R. increbescens* and var. *laticostata*, *P. minnesotensis* and *O. rogata*; in the Camarella bed (7) the same are rare and var. *laticostata* is not known; in the Lingulelasma bed (8) are *R. capax*, rare, *P. gibbosa*, *P.* cf *sericea*, rare, and *O. rogata*; in the Maclurea bed (9) none of these three groups of fossils are yet known: in the Triplecia bed (10) *R. capax*, rare, *P. præcosis*, *O. corpulenta*, *O. porrecta* and *O. futilis* are found; in the Diplograptus bed (11) *O. porrecta* is locally a secondary fossil; in the Orthoceras bed (12) *P. saxea*, *O. emacerata*, and locally *O. multisecta*; in the Leptæna bed (13) *R capax*, *P. recedens*, *O. corpulenta*, *O. emacerata*, *O. futilis*, and *O. ignota*; in the Orthis bed (14) *R. capax*, *R. anticostiensis*, locally *R. neenah*, and *R. perlamellosa*, *P. recedens*, *O. emacerata* and *O. tersa*.

Having determined the horizons or beds in the manner stated, and knowing the distribution of our fossils, we are enabled to compare them and it is at once conspicuous that the hypothetical times or intervals in which evolutionary changes took place do not coincide in different groups of species. For example, *Rhynchonella minnesotensis* (1 to 4) changes abruptly to *R. increbescens*, (5 to 7) between beds four and five; *Plectambonites sericea* (3 to 5), changes likewise to *P. minnesotensis* (6, 7) between beds five and six; *Orthis rogata* ranges from No. 4 to 8, not changing between four and five, nor five and six.

The source of the different "varieties" is either sudden and obscure evolution, or is from immigration of already different, contemporaneous species, and since the same "varieties" are found in other areas it is certain that immigration is at least the scource in most cases. It is evident that species were arriving and departing from the area during the building of the two series so that there is found a steady change of faunal peculiarities. Most often they came or departed during the interval between the beds, the same being thus divisional lines in the series. Some species may have evolved and others died away here, but of that we are never positively informed. When a species disappears at one horizon it may return.

The migration of species in this area during the Galena (Trenton) and Maquoketa (Hudson) periods was gradual when the fauna is taken as a whole into consideration, and there are many minor changes as illustrated in the groups of species already described, which make the division of the series into beds easy, and the delimitation of formations practicable. There are morever local peculiarities of all degrees besides those that are regional. *A priori*, one is not able to tell which species is of the greatest value for correlation but investigation soon proves some to be better than others. Very abundant species and large series of very closely related ones are of great importance because their relation to the strata is most easily proved. Isolated species like *Bellerophon wisconsensis* Whitf. (bed No. 2) which characterize one zone, and other common ones that are absent for a short time over the whole area like *B. bilobatus* Sow. are important guides that are not to be neglected in correlation. Of least value in the Galena and Maquoketa series is the common method of correlation by computing the percentage of like fossils since the identity of fossils does not prove strictly contemporeneous deposits, but only related faunas. In northeastern Iowa, as I have incidentally shown, paleontologists and geologists have recently mistaken the true Maquoketa (beds No. 11, 12), in numerous large exposures, for "Trenton" (beds 5, 4, etc.), and the next above the Maquoketa formation (13) for Galena (9, 8, etc.), and in fact a percentage computation of faunas might lead to the same mistake. Collections from different beds in two different localities may have a higher per cent. of like species than collections from equivalent deposits of the same bed at the two localities. The paleontologic evidence, therefore, that I have used in correlating in the Galena and Maquoketa series has not simply consisted of gross percentage computations, but upon the inductively determined limits, range and distribution of species, and in fact of the commonest species.

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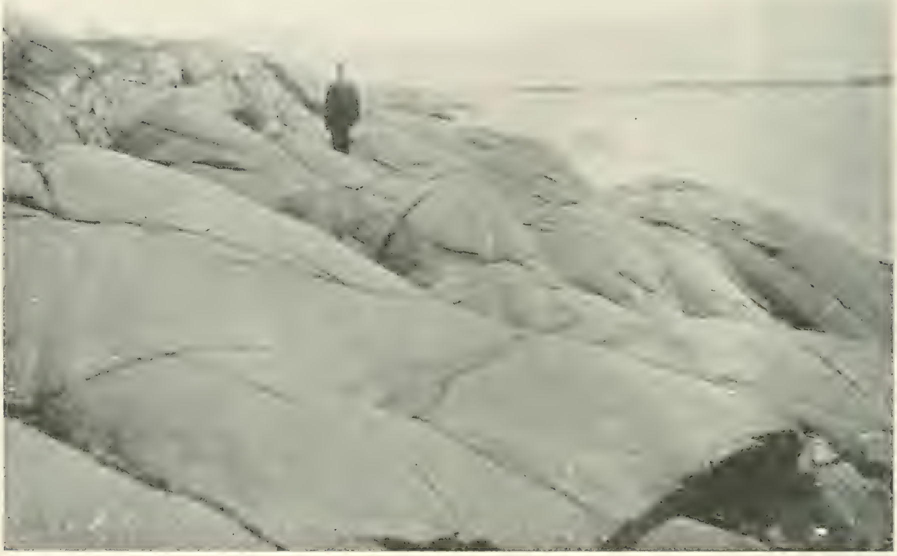

FIG. 1.—GLACIATED SURFACE, TURNAVIK ISLAND, LABRADOR.

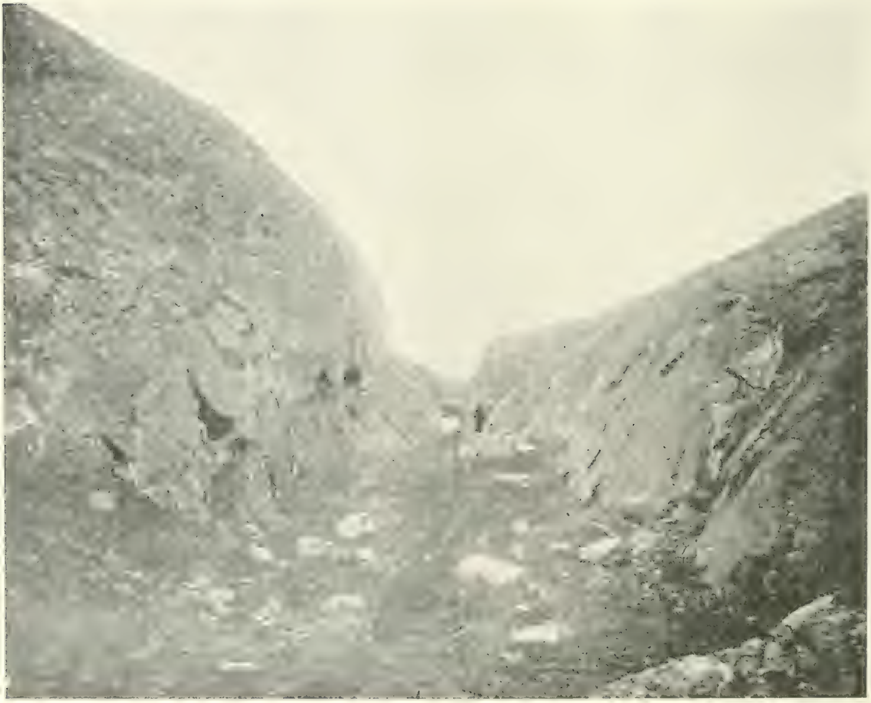

FIG. 2.—A DIKE CHASM SHOWING PREGLACIAL DECAY. TURNAVIK ISLAND, LABRADOR.

EVIDENCE OF GLACIATION IN LABRADOR AND BAFFIN LAND.

By Ralph S. Tarr, Ithaca, N. Y.

(Plate X.)

Route. The observations recorded in this paper were made by the writer during the summer of 1896, while a member of the Peary expedition to Greenland.* The steamer Hope, which carried the party, passed near the land along the entire eastern coast of Labrador, and an almost continuous view of this coast was obtained. Only one stop was made, at the island of Turnavik, in lat. 55° 15′. A landing was also made at Big island, in Hudson's strait, in lat. 63° and long. 71°, and several stops on the main Baffin Land coast, just north and northeast of Big island. On the return from Greenland, a stop was made at Niantilik harbor, on Black Lead island, in lat. 65°, long. 67°, on the south shore of Cumberland sound.

Turnavik Island, Labrador. As seen from the steamer, nearly the entire eastern margin of the Labrador peninsula has the rounded contour which is so characteristic of glaciated lands. This is particularly well shown on the hills near Turnavik, which is an island off the Labrador coast. The elevation of Turnavik is only two or three hundred feet in its highest point, and like most of these northern lands, the surface is for the most part bare rock, with very little covering excepting in the protected valleys, where, in some places, there is a deposit of till, and frequently a covering of peat. The rock is a porphyritic gneiss crossed by igneous rocks, and especially by diabase dikes.

Upon Turnavik island signs of glaciation are everywhere present; the rock surfaces are roches moutonnées forms, with very perfect outline, and upon these, glacial grooves and striæ abound. The perfection with which these delicate scratches are preserved in exposed places tells of the recency of the ice withdrawal; but perhaps not so much as would at first appear. Since the ice left this region, the lower portions of the coast have been submerged beneath the sea, and hence for some time protected from the action of the weather. On Baffin land, where the question of post-glacial elevation was studied,* it was found that there was a marked difference in the amount of weathering above and below the zone of former water covering. It is, therefore, probable that the freshness of the striæ near the sea level at Turnavik is only partly due to the recency of the ice retreat.

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*Besides myself, the members of the Cornell party were Prof. A. C. Gill, E. M. Kindle, J. O. Martin, T. L. Watson, and J. A. Bonstell. Prof. G. H. Barton was with us much of the time in this part of the expedition. (See Am. Geol., xviii, 1896, 379.)

Although the hills of Turnavik are well rounded, and show signs of decided ice scouring (Fig. 2, Pl. X), it is evident that the glaciation did not succeed in destroying even the details of the pre-glacial topography. Evidence of this is particularly strong in the dike valleys. These, even though extending at an angle to the direction of ice motion, are pronounced features of the present topography (Fig. 2, Pl. X). The pre-glacial decay along the line of these dikes was deeper than that on the enclosing gneisses, and the action of the ice scouring has not been sufficient to lower the gneisses to the level of this decay. Hence in various directions the island is crossed by dike chasms, which are deep and narrow, as well as remarkably continuous. In some cases at least the disintegrated material has all been removed, and the fresh diabase rock exposed in the bottom of the chasm. In other cases there is a layer of till, peat, or foreign rock in the bottom of the chasm; and hence in these places it is impossible to determine by surface indications whether all the decayed diabase has been carried away. This evidence of slight scouring is in harmony with that found in Baffin land and Greenland, and also in parts of New England.† It shows that pre-glacial decay was deep, and that the general ice scouring did not lower the surface far below the zone of decay in the weaker members of the rock series.

Northern Labrador. Near the northern end of Labrador the first doubt concerning the presence of ice action arises when the Kig-La-Pait mountain comes in view; and northward to Ogua-Lik and cape Mugford, and even as far north as the Four Bears (from Lat. 57° to 60°) the same doubt arises because of the angularity of the topography. From the evidence of the topography I thought that these high mountains, which rise from near the sea to elevations of from two to five or six thousand feet, had escaped ice scouring, though the rounded contours of the valleys indicated the presence of ice action in them. My first thought was that, though the ice had spread through the valleys, the elevated peaks had risen above the surface as peninsulas and nunataks, like those of the present Greenland coast. Later study in Greenland proved the danger of drawing inferences concerning the absence of glaciation upon the basis of topographic form as seen from a steamer several miles from the coast.* The rounded outline so characteristic of an ice-scoured country is good positive evidence of ice action, but the *absence* of such action is not of equal value in proof of the opposite. When the pre-glacial surface was high and rugged, the same amount of scouring that rounded the lower hills may have failed to produce rounded contours on the higher lands. Moreover a peak projecting into the ice is less eroded than the valleys whose surface is covered by the ice currents of greatest activity. In addition to this, the lower lands are longest covered, being the first reached and the last abandoned by a general ice sheet.

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*See Watson, Journ. Geol., v, 1897, 17.

†See Shaler on the Geology of Cape Ann, Ninth Annual Report U. S. Geol. Survey. Pl. LXII. Prof. Shaler interprets this as the result of sea action, but my studies lead me to the conclusion that the dike valleys are preglacial.

Therefore, although there is a striking difference in topography between the hills near Turnavik and the mountains around cape Mugford, I shall be very much surprised if future study proves that the higher hills were not covered and perceptibly modified by ice action. During the *last* stages of ice action these mountains no doubt rose above the ice as land. It was a source of disappointment that other plans prevented our landing and studying this highland portion of the Labrador coast. This region offers a splendid opportunity for determing the thickness of the northern portion of the continental glacier which spread out from the Labrador center; and in some one of the northern expeditions it should be made a stopping place for this purpose. The rounded topography of glacial regions reappears on the peninsula which forms the northeastern portion of Labrador.

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*This point is discussed in a paper to be published soon in vol. VIII, Bull. Geol. Soc. Am.

Southern Baffin Land, on Hudson's Strait. On Big island, and on the main Baffin land to the north of it, evidence of glacial action was found on all the hills that were visited. The rocks of this region are gneisses, and on the mainland these are very garnetiferous. Post-glacial disintegration has weathered these rocks very decidedly. The pre-glacial topography, which still forms the most striking features of the present land form, consists of valleys and hills which are mainly parallel to the strike of the rocks (about N 10°-30° E, magnetic). So numerous are these valleys that the surface outline is exceedingly irregular. Into some of the strike valleys the sea at present enters, and near the shore, drowned alleys and hills, completely submerged beneath the sea, form alternate channels and reefs, so that navigation near the shore is very dangerous. Several times the ship passed near some of these submerged hill tops, and once ran upon one, staying there until the tide went out and rose again to float her off.

Not merely are there these large pre-glacial valleys, but innumerable smaller ones, also parallel to the strike. So numerous are these that the surface of the hills is corrugated by ridges and minute valleys, where the hard and soft layers alternate. It is evident that these irregularities of minor degree are not of post-glacial origin, for the valleys are occupied mainly by ice-derived blocks of rock and by till (below the zone of former sea level, by sea-made deposits). The valleys extend diagonally to the direction of ice motion, and hence were not ground out by ice erosion. They certainly represent irregularities of pre-glacial origin, which the ice erosion has not been able to wear away; and, comparing the evidence from this with that found at Turnavik, it seems evident that less down-cutting was accomplished by the Baffin Land ice cap than by the Labrador sheet which overspread Turnavik.

The land in the southern portion of Baffin land rises to an elevation of over 700 feet within a few miles of the shore, and the ice has covered all of the hills. It is perfectly evident at a glance, and can be proved without even visiting the shore, that notwithstanding the many irregularities in detail of surface outline, the general topography is that of smooth and somewhat rounded contours. The action of the ice upon the higher hills is also shown by the roches moutonnées which abound; and the condition of the rock is likewise proof of ice action: for, although much post-glacial weathering has occurred, there is an absence of the quantities of decayed rock and talus that would be present in a region which had long been exposed to the weather. Glacial striæ of distinct kind were not seen; the weathering of the exposed rocks having been too great for them to remain. Some broad and rather deep grooves, apparently of this origin, extended N. 50°–60° E. (magnetic), and this coincides with the direction of the ice movement as determined by the form of the moutonnées hills. In the valleys there are deposits of glacial material, but till is so scarce that the surface is almost entirely either bare rock, or else blocks of gneiss derived by post-glacial frost action.* Transported pebbles of quartzite, slate, and fossiliferous limestone were frequently found on the hills and in the valleys, but the time at our disposal would not permit us to trace these to their source.

Cumberland sound, Baffin Land. Very nearly the same conditions were present in Cumberland sound, though the details of the pre-glacial topography are perhaps even more perfectly preserved. The surface of the hills is extremely irregular, and valleys and ridges of minute size, distinctly of pre-glacial origin, abound. On this part of Baffin land also, the glacier extended at least as high as 700 feet, and nothing in the topography indicated that the ice did not cover even the highest hills that could be seen. It was astonishing to find how little effect in smoothing the surface was accomplished by the ice invasion of this land; but very nearly the same condition exists on those parts of the Greenland coast, which were studied in detail. It is noticeable near Cumberland sound, as well as in Turnavik, and in Hudson's strait, and indeed in Greenland, that there are many basins of small size, surrounded entirely by rock. While some of these have no doubt been scoured out by differential ice erosion, the position of many of them along the line of weaker rocks, indicates that they represent differential pre-glacial weathering. The advance of the ice in these cases has served to remove the decayed rock, and perhaps to deepen the depressions formed by this action, though ice erosion would not in this case be the prime cause for the basin.

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*This notable absence of drift deposits is found throughout the northern regions so far visited. For some reason the ice that passed over these did not have much drift, just as now, the Greenland glaciers are not heavily laden.

Recency of ice withdrawal. Notwithstanding the absence of distinct rock striæ, it is evident, for several reasons, that the ice has not long been away from Baffin land. The marked weathering of the surface rock suggests considerable length of time; but in using this as a basis for an estimate, it must be remembered that the severe weather changes of the Arctic, evidently produce marked results in weathering in a very short time.* In the till beds, which were found in greater thickness and abundance in Cumberland sound than in the other places that have been described, there is much less evidence of modification. The striæ on the pebbles are still distinct, and the till not markedly decayed, nor even the weaker pebbles disintegrated. Weathering on the exposed and friable gneissic bed rock has been far more rapid than in the unconsolidated deposits in which frost action is able to produce less effect.

Evidence of recency of the ice withdrawal is also furnished by the lakes of Baffin land. Some of them have two outlets and others have more. This certainly could not have been possible had the water been overflowing the rims of the basin for any considerable length of time. It would not be long before one of the outlets, in its action of down-cutting, would so exceed the rate of work of the others that all but one would be abandoned. Pointing toward the same conclusion of recency is the fact that even where torrents enter shallow lakes from the higher hills, the materials that have been brought by the streams have not yet been able to build perceptible deltas in most of the lakes.

Conclusions. The conclusions to be reached from this very brief reconnaissance study of parts of Labrador and Baffin land are, in the first place, that all of the land, excepting possibly the highest parts of Baffin land and Labrador, has been buried beneath an ice sheet. The possible exceptions, in all probability, are not real cases of unglaciated land, but rather high land that rose *into* the ice, and in the early and later stages of glaciation extended *above* it, as is the case in Greenland itself at present. The direction of ice movement in Labrador was not determined excepting at Turnavik, where it was off shore. In Baffin land it was difficult to tell how the ice moved, because the striæ were destroyed by post-glacial weathering; but on the southern side the ice movement was apparently southeastward, as if Baffin land had been a separate center of ice dispersion.

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*See Tarr, Am. Geol., xix, 1897, 131.

The glacial action produced more effect in the down-cutting of the surface in Labrador than in Baffin land, for the surface features of the former are very much more rounded than those of the latter. Even near Turnavik, the ice cutting did not succeed in lowering the surface down to the level of the zone of weathering in the weaker rocks. In Baffin land the down cutting of the surface was even less pronounced. Both in Labrador and Baffin land there is evidence that the ice has withdrawn from these regions in very recent times. By comparison with studies that have been made in parts of New England it seems that the period since the ice left is much shorter in the northern lands. Comparing these northern regions with New England it seems certain also that the action of ice erosion has produced less effect upon the topography of the northern than the southern regions. On the other hand, as we proceed northward the effects of post-glacial weathering become more and more pronounced, so that the recency of the ice uncovering is more and more masked.

ESKERS INDICATING STAGES OF GLACIAL RECESSION IN THE KANSAN EPOCH IN NORTHERN ILLINOIS.

By Oscar H. Hershey, Freeport, Ill.

(Plate XI.)

Introduction.

The following pages present the result of an investigation into the character and origin of a remarkable series of ridges and knolls of stratified gravel and sand, situated mainly in the Pecatonica basin in northwestern Illinois and the adjacent portion of Wisconsin. They constitute a very important part of a drift sheet which, although unevenly distributed, is very thin and presents no true moraines. It has now become well known as the Kansan drift sheet, and it is exposed in a belt from thirty to fifty miles wide, extending from north to south across portions of the counties of Jo Daviess, Stephenson, Winnebago, Ogle, Carroll, Whiteside, Lee, and Rock Island, besides being widely distributed over western Illinois south from the Rock river. The district to which it is proposed to call special attention in the present paper includes the part of the hydrographic basin of the Pecatonica river which has been glaciated, and also the Leaf river basin immediately south of it, together comprising about 1,400 square miles.

The surface is essentially an eroded peneplain, having an altitude at the northwestern corner of about 1,025 feet above the sea, and sloping thence southeastward to about 900 feet at the southeastern corner of the district. In the western portion of the area a few elevations known as "mounds" rise from 75 to 200 feet above the peneplain. Eroded below this upland plain are broad shallow basins along the main lines of drainage. One of these, through which the Pecatonica river flows, is three to five miles wide and 75 to 100 feet deep. Trenched beneath the surface of this second and very imperfectly developed peneplain, are the present immediate valleys of the streams. The Pecatonica valley proper, belonging to this system, has a width of one to two miles, and an average depth of 100 feet. These valleys are, next to the main upland peneplain, the most prominent topographic features of northwestern Illinois and southwestern Wisconsin. Formerly they were much deeper than now, their rock floors being rarely less than 100 feet, and possibly in some places as much as 200 feet, beneath the present streams. The buried portion of the valleys was largely filled with a blue silt just previous to the glaciation of the region, and on this the drift sheet rests.*

DESCRIPTION OF THE STRATIFIED GRAVEL AND SAND.

The knolls and short ridges of stratified drift in the Pecatonica and Leaf river basins, although occurring at wide intervals throughout the district covered by the Kansan drift sheet, are principally collected into a number of irregular belts (shown in plate XI.), which cross the country parallel

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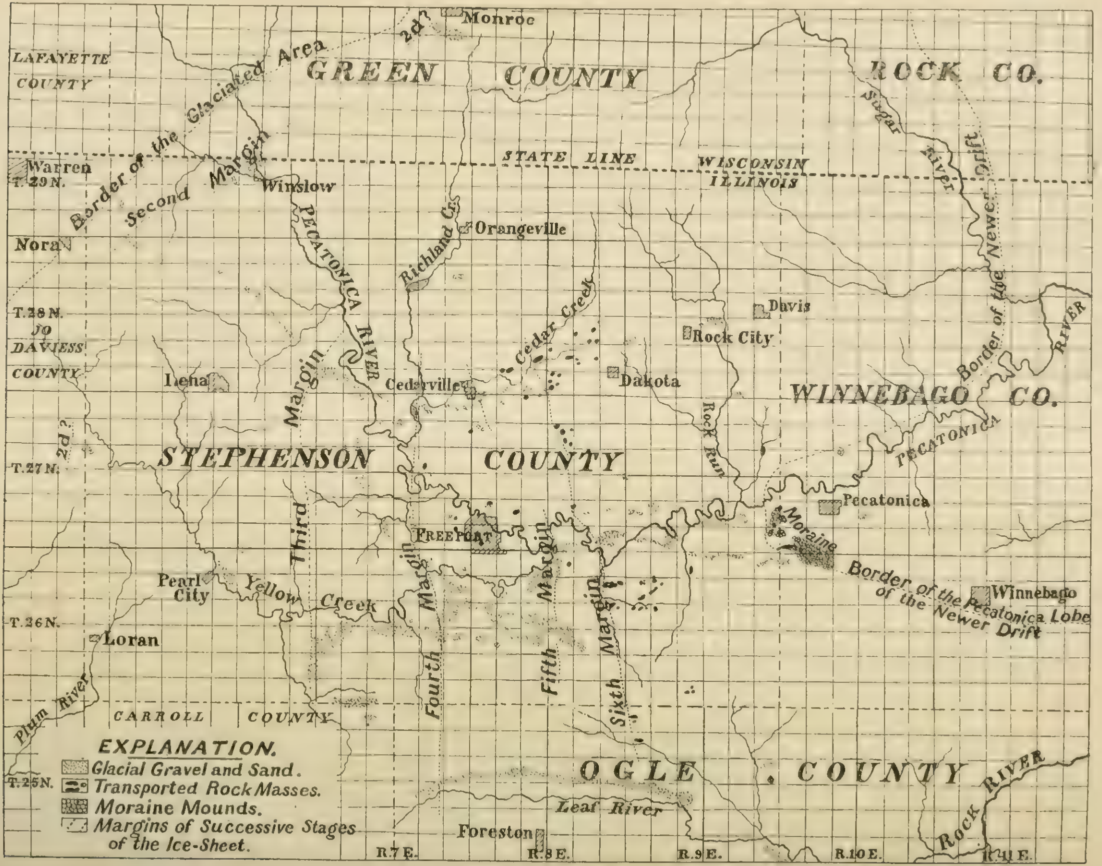
*For a complete discussion of the topography of the district the reader is referred to a recent article by the writer in the AMERICAN GEOLOGIST, vol. XVIII, pp. 72-100, August, 1896.

PLATE XI.



KANSAN STAGES OF GLACIAL RECESSION IN NORTHERN ILLINOIS.

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to the reputed direction of ice-movement. They are practically continuous throughout their entire length. On a hasty reconnoissance, this statement might be disputed; for the continuity of the deposits is now frequently interrupted by gaps. Many of these gaps are occupied by the alluvial planes of the present streams, and the ends of the ridges on either side correspond, clearly showing that the gaps have been produced by stream erosion subsequent to the abandonment of the region by the ice-sheet. There are other apparent gaps where subaërial erosion cannot explain the absence of the deposit. but in these places careful observation usually reveals some trace of it.

The main belts of stratified drift are found to follow the main lines of drainage wherever these agree with the general direction of the ice-movement. Three of these belts cross Stephenson county in a general east to west direction, which, beginning at the southernmost and most prominent one, may be named the Pecatonica, Cedarville, and Orangeville belts. The next belt northward seems indicated by a heavy development of stratified sand and gravel in and south of the city of Monroe, Wisconsin. This may be referred to as the Monroe belt. But the most prominent and sharply defined belt of the district is the one next south of the Pecatonica belt, which, from its fine development in the vicinity of the village of Adeline, in Ogle county, may be denominated the Adeline belt. Other less developed belts occur both north and south of those already mentioned, notably one in southeastern Carroll county, designated by Mr. Frank Leverett the Hazelhurst belt; but these have not yet been mapped and will not be considered in the present paper.

The five belts thus especially noted are not all that occur within the limits of the district, for there are still a larger number of shorter and less marked belts, which, although generally approximately parallel to the glacial movement, gradually converge toward the main belts, until finally the deposits of one are merged into those of another. If, instead of mapping the deposits by their present areal extent, lines are drawn through the crests of the ridges, the analogy with an ordinary drainage system will be remarkably close. The main or primary belts represent the trunk streams, and the secondary belts the tributaries.

Disregarding the secondary belts, we find that the main lines of drainage, as recorded in the primary belts, had an average distance between them of seven miles, although sometimes approaching within five miles and again diverging to eight miles. The situation of the secondary or branch belts has been accurately determined for the Pecatonica system only; but, by analogy with these, and relying on an abundance of fragmentary evidence gathered in other portions of the district, we may safely assert that tributary streams, as indicated by the branch belts, joined the main streams every few miles along their course, and at the point of greatest divergence were separated from them and from each other by a distance of no more than two or three miles. We thus see that the geographic distribution of the stratified sand and gravel in our district indicates that the outer portion of the ice-sheet, during the time of their formation, had a very complete system of drainage, provided these streams all flowed at the same time.

The Adeline belt. The eastern end of this belt is a short distance southeast of the village of Adeline in Ogle county. Its direction is at first slightly north of west to a point a few miles west of this village, when it turns to a direct west course, which it holds for about six miles, until it has passed the Illinois Central railroad. Thence it bends to the west-southwest, and persists in that direction to the end, not far from the Carroll county line. Throughout this distance of about twelve miles it is a well-defined ridge, having, however, a very uneven crest line. It may more properly be described as a series of mounds and short ridges standing in a line and connected at their bases. Only one short gap occurs, and that is where, a few miles east of the railroad noted, a branch of Leaf river breaks through the range. The base of the deposit has an average width of several hundred yards, and the ridge rises in some peaks to a hight of 110 feet above the creek at its base. It trends along the center of a preglacial valley, and, with its steep slopes and exceedingly irregular crest line, constitutes the most prominent topographic feature due to the drift in northwestern Illinois. Throughout the greater portion of the range it is clearly composed of only one ridge; but at its eastern end it broadens out and consists of numerous short parallel ridges. Similar division occurs also near the western end, but is less distinct.

At least a half dozen large openings have been made into this range of knolls and they reveal its internal structure perfectly. All its material is water-worn and generally well rounded. No particles smaller than grains of fine sand are present, while large pebbles are abundant, and in many cases coarse cobbles and boulders. Between these extremes there is every gradation, and the sizes are generally well sorted. The stratification is very distinct, and is chiefly of that class known as false bedding or diagonal stratification. In addition to the normal or original dip of the strata, portions of the deposit are much disturbed, apparently by settling. The topography of this range and its internal structure indicate that its relation to the associated drift-sheet is similar to that of the eskers of New England and New York.

The Pecatonica belt.—The eastern end of this belt has been overridden and destroyed by a later ice-movement. Its deposits appear in a small valley on the eastern edge of Stephenson county, and thence trend westwardly as a poorly developed line of knolls and short ridges which ascend a rock ridge probably 150 feet above the valley bottom, and thence descend into the valley of the Pecatonica river at the village of Ridott. In crossing the high rock ridge, the sand deposit consists of a small and narrow ridge never exceeding 25 feet in hight, and it continues with almost perfectly regular contours for a mile or more, then attenuating, only to rise a short distance beyond in a similar ridge. About a mile and a half north of this narrow belt, another comes down over the slope of a rock ridge, and forms several prominent cone-shaped mounds in the valley near the river. Its extension westward is indicated by an undulating topography with gravel outcrops, trending west-northwest until cut off by the river. Both of these belts can be traced by a line of knolls to an apparent junction on the north bank of the river about four miles east of Freeport. Here about 500 acres are covered with a well marked deposit of gravel and sand which rises into smooth ridges and some very steep knolls 60 to 75 feet above the river. Farther west, toward Yellow creek, the belt is marked by at least four distinct ridges, the northern-most of which stands in the center of the valley, while the most southern one partly rests on the slope of a rock ridge. These four ridges are parallel and about 1,000 feet apart. They end abruptly at the western end, where they are being eroded by Yellow creek and the Pecatonica river; excepting that the southern one is continued southwestward by a heavy deposit, which, however, shows subdued drift contours.

The belt has now left the valley of the Pecatonica river and henceforth occupies the preglacial valley of Yellow creek, which it has so obstructed as to turn the stream into a new course for eight miles. Several small parallel ridges continue the belt to its next heavy development, three miles southwest of Freeport. Here we find a roughly circular series of mounds and ridges apparently embossed on the eastern slope of a ridge, which resembles a rock ridge, but crosses the old Yellow creek valley at a right angle. Well sections show it to be composed of drift, partly till. Just east of this ridge the main belt of stratified drift is joined by a well marked secondary belt, which comes down from the east over an upland country averaging 125 feet above the valley bottom of Yellow creek. Near the same place a narrow belt apparently diverges from the main belt and trends northwest and then nearly due north. Its length is about three miles, and it is marked by a line of cone-shaped knolls and short ridges, which is crossed in going westward from Freeport at the distance of about two miles from the city. Its trend is anomalous, for it is apparently at right angles to all the other belts of the region.

On the western slope of the ridge crossing the ancient valley of Yellow creek, the main belt is continued by several parallel broad ridges, evidently containing much material but displaying no decided drift topography. These ridges culminate south and southwest of the village of Bolton in the most prominent accumulation of stratified drift of the Pecatonica belt. It covers at least 1,000 acres and rises into steep-sided parallel ridges attaining a maximum hight of perhaps 100 feet above the adjoining lowlands. This finely developed deposit dies away to the west into what appears to be a sand plain, but which lies mostly below the present creek level and cannot well be studied. Northwestward occasional sand ridges appear and continue the belt to its extreme end on the western county line, northwest of the village of Kent, and only a few miles back from the outer drift margin. But that portion of the belt which lies west of the heavy deposit at Bolton cannot be traced continuously and is poorly developed, so that the belt may be terminated properly at Bolton village. Its length, with this limitation, is twenty miles. The aggregate amount of material which it contains is several times as great as that of the Adeline belt, but it is scattered over a greater width; and, except at a few points of special development, it does not show such a marked topography. Consequently, while the Adeline deposit has been frequently described and discussed, no mention has been made of the similar belt in the Pecatonica and Yellow creek valleys.

The most characteristic features of the Pecatonica belt are (1) its compound nature, there being almost invariably two and sometimes as many as five parallel ridges, which may be traced often for half a dozen miles, when they either diverge to the branch belts or die out altogether; (2) the size of its material, averaging finer than in any other main belt of the district; and (3) the suddenly increasing development which the belt presents at distances of every few miles.

The Cedarville belt.—Deposits belonging to this belt are first met with in the valley of the Rock run about one and a half miles east of Rock City. It trends thence west-southwest, but as it is obliged to pass across an elevated tract of country, and as it is much mixed up with another class of drift phenomena (knolls of angular fragmental limestone), it cannot be definitely traced until it reaches the valley of Cedar creek. Thence to its western end it is very distinct, consisting of a single "ridge" which is marked by a line of cone-shaped mounds. Southeast of Cedarville there is an area of special development where it rises into sharp knolls 80 or 90 feet in hight. Here it has obstructed the ancient valley of Cedar creek, compelling the stream to cut a gorge on the north side of the village. The next area of special development is in the angle formed by Cedar and Richland creeks near their junction. West of the latter stream it is compelled to cross a high rock ridge, and upon its descent into and crossing of the valley of the Pecatonica river, it is found to have made a rather sharp bend to the northwest. In the village of Damascus it is well represented, and one mile northwest from there it rises into high hills which are remarkably steep and comparable in size with those which make up the Adeline belt. Northwestward from this area of special development, it extends up a small valley as a straight line of high, very steep, cone-shaped knolls, which again culminate about three miles northeast of Lena. This I would prefer to consider as the western end of the belt, for, although its extension northwestward nearly to the edge of the Driftless Area is marked by a discontinuous line of knolls, beyond the point of special development above indicated it has ceased to form a well marked deposit. Limited thus, its length is about twenty miles.

The Orangeville belt.—The mapping of this belt is as yet very incomplete, and its situation, except at a few points, has not yet been definitely determined. Its existence as a main belt is known from the fact that, in going northward from the Cedarville belt along any line, no stratified drift is encountered until on a belt which passes about two miles south of the village of Orangeville, when indications of waterworn gravel and sand are invariably met with. One deposit, probably corresponding to the "areas of special development" in the other belts, occurs on a hillside two miles due south of Orangeville. The chief point of development, however, is found just north of Winslow in the Pecatonica valley, where it rises into a very prominent knoll and a number of associated ridges. Here the belt terminates.

The Monroe belt.—Deposits of stratified gravel and sand, occurring partly in Monroe, Wisconsin, but chiefly southward, have been described by Chamberlin and Salisbury in the Sixth Annual Report of the U. S. Geological Survey. I have examined the deposit south of the town, and, from its heavy development, its northwest and southeast trend, and its apparently fitting into our system of glacial drainage, I consider it as the western end of one of the main belts. It probably corresponds to one of the "areas of special development" of the more southern belts; but southeastward from Monroe it may be scarcely traceable, there being no valleys to favor its development.

Having completed this brief description of the main belts, I will dismiss the secondary belts by the statement that they are in every way similar to the others, except that they are less strongly developed and more inclined to become discontinuous.

There are certain features that are common to all the belts, which may be detailed as follows:

1. They are not confined to any level but cross ridges of any hight, in several cases 150 feet or more above the present bottom of adjoining valleys. However, they are best developed at lower levels, and the most prominent knolls and ridges stand in the center of valleys.

2. They endeavor to follow valleys, if such can be found trending in their direction. Their situation is apparently less affected by the lower cañon valleys than by the upper basin-like troughs. They will not bend from a direct course upon encountering a low ridge, but are readily compelled to change direction upon meeting one of the high ridges which constitute the remains of the peneplain.

3. When they are in a narrow valley there is usually but a single ridge, and only few secondary belts; but in such a wide basin as that of the Pecatonica river and Yellow creek there are a number of parallel ridges.

4. The prominence of a belt and the amount of material which it contains are dependent largely on the size of the valley or basin in which it occurs. Where it is compelled to cross the peneplain without any favorable basins or valleys, it is so attenuated as to be often difficult to trace, while the same belt passing into a valley becomes conspicuously developed.

5. By far the most important feature of the gravel and sand belts of this district is their habit of suddenly passing into areas of marked development, at intervals averaging two or three miles apart. It is important to determine whether these areas are original or have been produced by subsequent unequal erosion of the belts. The glacial origin of these "areas of special development," which, for convenience in discussion I shall denominate *special areas*, is undoubtedly not merely apparent. It is true that commonly they are portions of the belt where coarse gravel is most abundant, and this has protected the deposit from being as deeply affected by subsequent erosion as are some other portions; but, on the other hand,

several of the most prominent areas consist almost exclusively of fine sand, and, although they have been deeply eroded, they still retain their prominence over neighboring portions of the belt. Post-Kansan erosion (chiefly Aftonian) has removed a large part of the deposits, and to it is due mainly the present topography of the belts. The higher knolls are those portions which, being capped with coarse gravel, were less deeply eroded. The original topography can sometimes be restored by studying the internal structure. The ridges thus become smoother and more regular, but the special areas are not obliterated. In short, after a careful study of the region, no doubt can remain that originally the belts of stratified drift ridges and knolls had these points of special development.

THE MANNER OF DEPOSITION OF THE STRATIFIED DRIFT.

When the "iceberg" theory was favorably received to explain the glacial phenomena of North America, the range of gravel hills in the Leaf river valley was attributed to the action of marine currents in the sea, which was supposed to have covered the entire glaciated area. Later, when the glacial deposits were recognized to be due to the action of land ice, and after the significance of the terminal moraines had been determined, this range of hills, probably because of its being at right angles to the glacial border, was classed with medial moraines. During the past ten years, however, its true nature has been generally recognized, namely, that it is the deposit of a stream which flowed on, through or under the ice, and which had a course at right angles to the border of the ice-sheet or approximately parallel with the direction of ice-movement; in short, that it belongs to the class of glacial drift deposits included under the term *eskers*. I shall assume, as needing no demonstration, (1) that the stratified gravel and sand of the Pecatonica and Leaf river basins owe their existence to a series of streams which resulted from the melting of the border portions of the ice-sheet; and (2) that these streams had walls or banks of ice, the deposits being laid down mainly within the margin of the glacier. It will be interesting, however, to discuss some of the minor particulars, such as (a) whether these streams flowed in channels melted into the ice, or in tunnels; (b) whether the deposits were laid down at the mouths of the streams or along their entire course; (c) whether the ice was in motion during the existence of the streams; and (d) whether the front of the ice-sheet remained stationary during the entire period in which these deposits were formed.

It is necessary, first, to determine the origin of the material; and this may be divided into two classes, foreign drift and local material. To the former class are referred all pebbles and boulders which have come from a greater distance than the western edge of the Niagara terrane in southeastern Wisconsin and northeastern Illinois. In the latter class are included pebbles of Galena limestone, white chert from the residuary clay of the Galena terrane, and the Freeport gravel.*

None of the so-called local material has come from a greater distance than sixty miles. Consequently, when we find that at least 90 per cent. of all the material of a size exceeding one fourth of an inch, in the gravel-knolls and ridges, is of the local class, we know that at least that percentage of the coarser portion of the deposit was gathered up within sixty miles from its present position. But when the percentage of local and foreign drift is studied in detail in the several knolls, it becomes yet more significant. Two miles east of the city of Freeport, several knolls, standing well out from the rock slopes of the valley, are found to consist to the extent of 95 per cent. of Freeport gravel and highly ferruginous sands, which were probably derived from the same formation. The courses of the streams that deposited these knolls can be traced eastward along various ridges and mounds for about three miles, and in every exposure of the interior nearly the same percentage of Freeport gravel prevails. So far as traced, these streams nowhere come in contact with the rock ridges which bound the valley. Just south of and parallel with the

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*The Freeport gravel is an ancient river-gravel, in which the pebbles are light brown in color and mostly have a peculiar semi-polished appearance. It has never been observed *in situ* within the district, although intelligent well-drillers report penetrating occasionally at a moderate depth in the larger valleys, a red gravel quite distinct from the drift, both lithologically and stratigraphically. From that deposit the brown river gravel distributed through the drift of the Pecatonica valley has probably been derived. Further evidence of its local origin will be presented in the text. Its designation as Freeport gravel is intended as temporary, until its true nature can be ascertained or it can be correlated with gravels discriminated and specifically designated in some other district.

esker ridges which contain this gravel, another stream course is indicated by an esker, but in the extensive excavations which have been made into it, a half hour might be spent in searching for a single pebble of the Freeport gravel. Instead, it appears to be replaced by well-rounded pebbles of Galena limestone which constitute 90 per cent. of the coarser material. Now, the till or unstratified glacial drift of the immediate vicinity, or of any part of the district, while it contains a very large percentage of Galena chert and also a considerable amount of Galena limestone, has comparatively little of the Freeport gravel, and not nearly a sufficient amount of local limestone pebbles to supply them in the percentage found in this southern esker. The origin of these pebbles in the stratified drift, however, is nicely explained by the fact that the stream passed across a ridge of Galena limestone about a half mile east of the excavations noted. Moreover, this was the only rock ridge with which the esker stream came in contact within several miles, and its large percentage of Galena limestone must have been derived from this source. The streams farther north failed to reach the limestone ridge, but instead eroded a deposit of Freeport gravel, which they probably found at low levels and carried within a few miles to a hight of at least 90 feet. It is this great abundance of the Freeport gravel in certain knolls, and its almost total absence in others of the same system, which supply the strongest proof of its local origin.

In the Cedarville belt the method of gathering the coarser material is equally plain. It passes through a country in which the hills are higher and closer than in the southern portion of the district, and there was better opportunity for the streams to come in contact with the rock ridges. Consequently we find many deposits of coarse gravel and cobbles in which 95 per cent. is Galena limestone, and one large deposit in which 99 per cent. is of this material. An examination of the till in that portion of the district shows that on an average it does not contain 5 per cent. of pebbles of Galena limestone, and they are almost invariably small. This statement is not made at random to support a theory, but it is the result of repeated examinations of the ordinary drift of that region. It is evident that the major portion of the coarse pebbles and cobbles in the knolls was eroded from the ridges by the stream itself. Whether this material had previously been loosened and broken up by the action of the ice is immaterial to my present purpose, which is to prove that the streams did not flow at a level above the tops of the highest hills on which the ice-sheet rested. In nearly all cases where a gravel deposit occurs within two miles west of a prominent rock ridge, it contains beds of coarse pebbles and cobbles which are almost exclusively of Galena limestone.

[*To be continued.*]

EDITORIAL COMMENT.

AN IMPORTANT AID TO THE INVESTIGATOR AND GENERAL STUDENT.

"Where has this subject been previously treated?" is a question perpetually recurring to the investigator, and the answer is never satisfactory. Not only is the body of geological literature so large that no individual can cope with it, but its bibliography has not been successfully attempted by any organization. Nevertheless, there are numerous works, such as partial bibliographies, indexes to libraries and serials, and reviews of special subjects, which may be of great use to the student if only he is aware of their existence and knows where to find them. A real need has therefore been met by the bibliographical committee of the International Congress of Geologists, in preparing its "Catalogue des bibliographies géologiques," which gives a classified list of all partial bibliographies of geology known to exist, either in print or manuscript. How well the need is met can not be told until it has been practically tested by use, but the volume bears witness to the most earnest and painstaking endeavor, and those who examine it can hardly fail to be astonished at the very large number of existing sources of information as to the extent and character of the literature of geology. Emm. de Margerie and his colleagues on the committee have assembled no less than 3,918 separate titles of bibliographies and allied works, and have described them with such fullness as to make a volume of 750 pages. Some of the works entered, like the catalogue of the Royal Society of London, contain lists of publications of individual geologists; others are bibliographies of particular countries or districts; and yet others pertain to the literature of special geological subjects. With reference to these various limitations of scope the entries have been given an elaborate classification, and they are also indexed, so that one who wishes to know what has been written on a particular subject or a particular district can readily ascertain whether there is a known list of the writings he seeks.

Our readers may recall that the committee on bibliography was appointed at the Washington session of the Congress and that it made a preliminary report at the Zurich session. Funds for the publication of this volume were furnished by the local committees of those Congresses, but the cost of printing has somewhat exceeded the estimates, and the committee are endeavoring to meet the deficit by selling such copies of the catalogue as remain after supplying the members of the two Congresses. Not only do we hope that this may be accomplished, but that a large number of our university and public libraries may acquire this valuable work of reference, for it will be found a great convenience wherever any original research is undertaken in general geology, or in any of its departments. The price, for the United States and Canada, has been fixed at $5.00, and copies can be had from the American member of the committee, Mr. G. K. Gilbert, of the U. S. Geological Survey, Washington, D. C. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Sixteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1894–'95. CHARLES D. WALCOTT, Director.—Part I. Director's Report and Papers of a Theoretic Nature: pp. xxii, 910: with 117 plates, and 168 figures in the text; 1896.—Part II. Papers of an Economic Character: pp. xix, 598; with 42 plates, and 65 figures in the text; 1895.—Part III. Mineral Resources of the United States, 1894, Metallic Products: pp. xv, 646, with 23 plates, and 9 figures in the text; 1895.—Part IV. Mineral Resources, 1894, Nonmetallic Products: pp. xix, 735, with 6 plates; 1895. Four stately volumes constitute this annual report. The third and fourth treat of the progress and statistics of mining and quarrying in this country during the calendar year 1894, as compiled under the direction of Dr. DAVID T. DAY, which reports previously have been issued in a separate series. These volumes, and also the second, which contains results of investigations that are likewise of immediate value for guidance in commercial and industrial enterprises, were issued nearly a year in advance of volume I, which, however, appeared within about a year after the end of the fiscal year to which it relates.

This first report of the present director fills 130 pages, noting the plans for the year, the appropriations, and their allotment to more than thirty field parties in geology and paleontology. It gives brief outlines of the work done by these parties, and by the divisions of chemistry, hydrography, and topography. In the last named department surveys and mapping are being extended far in advance of the detailed geologic surveys. The total appropriation for the Geological Survey, in all these departments, during this fiscal year, was $497,990.

Both the strictly geological and the topographical work are widely distributed. In geological work thirteen parties were employed in the Appalachian and Atlantic coastal regions, receiving amounts that varied from $600 to $7,500; and in the central and western parts of the country fourteen parties, with similar allotments, of which four worked wholly or partly in Colorado and four in California.

The largest amounts for topographical work were allotted to Colorado and California, $20,000 each; Texas received $12,000; New York, Georgia, South Dakota, Nebraska, and Oregon, each $10,000; while in eleven other states topographical surveys were allotted from $2,000 to $5,000 each.

In pages 133-414, with plates II-LXXXV and 66 figures in the text, Prof. O. C. MARSH reports on the "Dinosaurs of North America." This elaborate paper presents the author's matured classification of this remarkable group of Mesozoic reptiles, as now known from this continent. The material on which the descriptions are based has been in progress of collection more than twenty years, and has led the author across the Rocky mountains a still greater number of times. Further discussion of the affinities of the class, or its relationship to other classes of reptiles and to birds, will be given in forthcoming monographs.

"Glacier bay and its Glaciers," by HARRY FIELDING REID, is the theme of pages 415-461, with plates LXXXVI-XCVI. The maximum extent of the Muir glacier, to the Beardslee islands, was followed by a recession, which is thought to have been comprised within the past 100 or 150 years, withdrawing the ice front about twenty miles. Between 1880 and 1890, the continuous annual recession averaged about 750 feet, being at the rate of a mile in seven years; but between 1890 and 1892 an advance of about 900 feet took place, due probably to an unusually large snowfall in these years.

Prof. LESTER F. WARD discusses "Some Analogies in the Lower Cretaceous of Europe and America," in pages 463-542, with plates XCVII-CVII and figures 67-69. The Potomac formation of the United States is compared with the Wealden of England. The geologic relations of these two formations, and their paleontology, especially their plant remains, are regarded as evidence of closely equivalent age. The Cretaceous and other Mesozoic formations of Italy and Portugal are also concisely reviewed.

Pages 543–570, with figures 70–100, by T. NELSON DALE, describe "Structural Details in the Green Mountain Region and in eastern New York." The author shows, by the excellent illustrations, how the individual ledges, and even hand specimens, in an area of mountain crumpling often display results of folding, cleavage, and brecciation, which are traceable to the motions of the rock particles participating in the disturbances of the great mountain masses.

In pages 571–874, with plates CVIII–CXVII and figures 101–169, a very thorough study is presented by Prof. CHARLES R. VAN HISE, under the title, "Principles of North American Pre-Cambrian Geology," with an appendix, by LEANDER MILLER HOSKINS, on "Flow and Fracture of Rocks as related to Structure." Folds, cleavage and fissility, joints, faults, and the varied phases of metamorphism, are carefully and instructively considered; after which the historical geology of the Archean and Algonkian districts of the United States and Canada is reviewed, attention being especially directed to illustrations of the principles earlier stated.

The concluding paper of volume I, by HENRY GANNETT, chief topographer, gives a "Summary of the Primary Triangulation executed by the United States Geological Survey between the years 1882 and 1894." About a sixth part of our national domain, excluding Alaska, has been covered by this triangulation.

Volume II.—The first paper of volume II is by WHITMAN CROSS and R. A. F. PENROSE, Jr., on the "Geology and Mining Resources of the Cripple Creek District, Colorado," comprising pages 1–209, with 14 plates and 37 figures. The gold production of this district during the first three years of its development, 1892 to 1894, is estimated as about $7,000,000; and the value of the ores shipped from the mines, containing free gold and telluride of gold, varies from $20 to several thousand dollars per ton. The veins occur at fault planes of slight displacement in and near the area of eruptive rocks which overlie and partly surround a volcanic vent and which are themselves surrounded by granite. It is believed that the gold and associated vein minerals were derived by solution from the volcanic rocks, and, to a less extent, from the adjacent granite.

Pages 211–276, with plates XV–XVII and figures 38–41, are entitled "A Geological Reconnaissance across Idaho," by GEORGE H. ELDREDGE. The belt examined extends from southwest to northeast by Boise and Salmon City. The rocks are referred to the Archean, Algonkian, and Paleozoic eras, with Tertiary sandstones and clays, abundant Quaternary gravels, and eruptives which are regarded as possibly of all ages from Archean to Recent.

Prof. N. S. SHALER, in pages 277–341, with plates XVIII–XXIV, treats of "The Geology of the Road-building Stones of Massachusetts, with some Consideration of Similar Materials from other parts of the United States." Laboratory tests of road materials, which have been performed at Harvard University for the highway commission of Massachusetts, are described, with detailed statement of their results, and with notes of the sources of such stone, partly boulders and cobbles of the glacial and modified drift and partly quarries. The plates illustrate eskers, morainic boulder belts, residual boulder pavements on the seashore where cliffs of till are being washed away, and the contiguous coarse shingle beaches, besides views of trap dikes in Brighton and Somerville.

Mr. J. EDWARD SPURR, in pages 343-455, with plates XXV-XXXIV, and figures 42-47, presents an excellent report on the "Economic Geology of the Mercur Mining District, Utah," with an introduction by S. F. EMMONS. From all the mining districts of the Oquirrh mountains, first worked in 1869, it is estimated that, up to Jan. 1, 1894, more than $50,000,000 of gold and silver had been obtained. In 1890 the remarkable Gold ledge of the Mercur district, in these mountains, was discovered. The ore-bearing horizon is in the Lower Carboniferous limestones. Two distinct periods of mineralization produced, first, the Silver ledge, carrying silver with some antimony and copper, but no gold; and, at an undetermined later time, the Gold ledge, about 100 feet higher, which is a bed of decomposed limestone and shale, carrying realgar and cinnabar, with a low but comparatively uniform percentage of gold, but no silver. In both periods the ores were deposited mainly in the porous or brecciated zone along the lower contact of intrusive porphyry sheets. Mr. Spurr thinks that the minerals of the Silver ledge were pressed out of the cooling porphyry with the included water and brought to their present position in aqueous solution; but that the subsequent mineralization of the Gold ledge was due to fumarolic vapors ascending from some body of igneous rock which did not reach the surface.

Mr. FREDERICK HAYNES NEWELL, in pages 457-533, with plates XXXV-XXXIX, and figures 48-57, treats of "The Public Lands and their Water Supply;" and the final paper of this volume, in pages 535-588, with plates XL-XLII, and figures 58-65, is by the late Mr. ROBERT HAY, on the "Water Resources of a Portion of the Great Plains." One of the maps of Mr. Newell's paper shows, for the western half of the United States, the areas of forest (about 15 per cent.); of woodlands having a sparse growth of timber (17 per cent.); of irrigated and improved lands (7.33 per cent.); and of treeless country (61 per cent.). More than three-fourths of the treeless portion are rated as grazing lands; and only seven per cent. of all as desert. The district carefully examined and here reported by Mr. Hay is a north to south belt, in southwestern Nebraska, western Kansas, and eastern Colorado. The topography, hydrography, and geology, are described with relation to irrigation.

Volumes III and IV.—For the year 1894, here reported, the metallic products of the United States had a value of $218,168,788; and our non-metallic mineral products amounted to $308,486,774. With the addition of a million dollars for estimated mineral products not specified in the tabulation, the total is $527,655,562, being over a thousand times the expenditure, during that year, for the United States topographical and geological surveys. Values of the production of some of the larger items of the list were as follows: Bituminous coal, $107,653,501; anthracite coal, $78,488,063; pig iron, $65,007,247; silver, $64,000,000; gold, $39,500,000;

copper, $33,141,142; building stone, $37,377,816; petroleum, $35,522,095; and natural gas, $13,954,400. The production of iron was 6,657,388 long tons, or an average of 200 pounds apiece for each man, woman and child of our population.

The compilation of these reports and statistics has been carefully done by many specialists under the direction of Dr. Day. It is a great advantage to the industrial interests of the United States that his reports be promptly published, as early as is consistent with their accuracy and completeness. The promptitude of issue of the present volumes therefore deserves most hearty commendation. It is further to be hoped that similar early publication and distribution will be accorded likewise, so far as shall be practicable, to the other work and investigations of the survey, embodied in its bulletins and monographs. W. U.

The Geology of the Fox Islands, Maine: A Contribution to the Study of Old Volcanics. A dissertation submitted to the Board of University Studies of the Johns Hopkins University for the degree of Doctor of Philosophy. By George Otis Smith. (76 pp., 2 pls.; Skowhegan, Me., 1896; published by the author.) The Fox islands are situated in about the center of Penobscot bay, eight miles out from the mainland. North Haven and Vinal Haven are the principal islands of the group and among the larger of the many islands along the Maine coast. Their most striking topographic feature is an extremely sinuous coast-line. Dr. Smith says that, while a circumference of thirty miles would encompass the entire group, the coast-line of these two islands alone measures nearly one hundred and fifty miles. This feature is due to the depression of a surface diversified by subaerial erosion and only slightly modified by glaciation. Wave action is reducing the complexity of the coast-line, cutting back the salient and filling in the re-entrant angles of the coast. Thus an increasing simplicity will accompany and indicate the increasing age of the coast-line.

The geological research of Dr. Smith has been along three lines: the investigation of the geologic relations of the different members of the rock series, the determination of the original nature of the rock-types represented, and the tracing of subsequent changes. With the results of this three-fold research thoroughly mastered, he is able to give an admirably clear outline of the geologic history of the islands.

There are seven geologic formations represented, comprising a considerably larger number of rock-types.

THE NORTH HAVEN GREENSTONE COMPLEX covers the greater part of North Haven and is composed of diabases, amygdaloidal and compact, with accompanying pyroclastics. From this original material greenstones have been produced through the processes of saussuritization and chloritization chiefly. A columnar structure, conspicuous in the field, is thought to be due primarily, to contraction on cooling, and secondarily, to modification by subsequent dynamic action. The prisms produced by contraction have been rounded and a schistose matrix formed by dynamic action. This greenstone complex bears internal evidence of superior age, and is also found to underlie a basal conglomerate of the Niagara period, hence the formation is pre-Niagara. It is also the oldest formation on the islands.

THE NIAGARA SEDIMENTS occupy an insignificant area on North Haven island, and a still smaller area on Stimpson's island, but have proved on account of their fossiliferous character, of extreme value in determining the ages of the geologic series of the islands. The best section is on North Haven island and is given below in descending order:

Sandy shale and quartzite	65	feet
Concealed	70	"
Grey shale	49	"
Conglomerate and shale	12	"
Red shale	55	"
Conglomerate	1	"
Red shale	10	"
Grey shale	37	"
Concealed	17	"
Grey shale and limestone	71	"
Quartz-porphyry, intrusive sheet	10	"
Concealed	16	"
Grey limestone and shale	104	"
Grit, coral fragments	1¼	"
Sandy limestone	4	"
Concealed	42	"
Basal conglomerate	16	"
	580¼	feet

The formation possesses a steep southerly dip and a general strike between N. 85° E. and N. 40° E. Some eighty fossil species have been studied by Beecher and are distributed through the following classes: Hydrozoa (3), Actinozoa (12), Crinoidea (2), Annelida (2), Trilobita (3), Ostracoda (3), Bryozoa (2), Brachiopoda (27), Pelecypoda (6), Gastropoda (6), Pteropoda (1) and Cephalopoda (8). This fauna includes a few characteristic Clinton species and a larger proportion of Niagara species. On this evidence the fossiliferous rocks of North Haven are considered "as representing a faunal equivalent to the Clinton and Niagara, with a decidedly strong Niagara facies."

An interesting suggestion by the author is that the color of the red shales is not due, as is frequently the case, to the absence of an attrition sufficient to separate the coating of ferric oxide from material derived from subaerial decay of crystalline rocks, but that it is due to the presence of tufaceous material deposited in shallow water. Thus the red shales are the earliest evidence of volcanic activity on the islands.

THE CALDERWOOD'S NECK SCHISTS comprise a series of quartzitic slates, banded schists and massive quartzites, and occupy the northern half of Calderwood's neck. Contact phases of the Calderwood's Neck series in proximity to the granitic and volcanic rocks are represented by felsites. This series is composed of non-fossiliferous, metamorphosed sediments, and, while it is impossible to determine their age relative to the Niagara series, they seem to be an older formation deposited under distinctly different conditions.

Red, yellow and purple volcanics are conspicuous along the bold shores of the Fox Islands thoroughfare, whence they have been designated the THOROUGHFARE VOLCANICS. These lavas and their corresponding fragmentals include three rock-types: andesites, diabase porphyries and quartz-porphyries. These ancient andesites vary somewhat in mineralogical composition and in structure and admit of further classification as pyroxene-andesite, hornblende-andesite, basaltic andesite, andesite-porphyry and amygdaloidal andesite. Reference will again be made to these rocks in the discussion of terminology. A volcanic conglomerate made up of rounded andesite fragments, ranging in size from that of a boulder several feet in diameter to that of coarse sand, is the most important of the pyroclastics. Flow breccias and tuff breccias are also found with gradations to tuffs of the finer volcanic dust. The ash-structure, characteristic for deposits of finely divided glass, is displayed by these fine grained tuffs, and is figured by the author.

The pyroxene-andesites and andesite-porphyries are the lowest members of the series and are immediately overlain by the volcanic conglomerate, which in turn is overlain by basaltic andesite, the more acid hornblende-andesite, acid and basic interbedded tuffs and amygdaloids. The limited flows of quartz-porphyry are associated with the acid tuffs. The determination of the age of these volcanics rests upon their relation to the Niagara sediments. While at one locality (Ames knob) the volcanics overlie, without marked unconformity, the upper members of the Niagara series, at another locality (Stimpson's island) some presumably Niagara sediments are interbedded with the lower members of the volcanic series.

These facts justify the assumption that the volcanic activity began in Niagara time. No evidence of the site of the volcanic vent was obtained. The sediments, volcanic and otherwise, indicate that the area of volcanic action was near the sea level and underwent more or less frequent oscillations of level.

Nor did volcanic activity close with the Thoroughfare series, but later activity is represented by the *Vinal Haven acid volcanics.* These acid volcanics occupy the northwest end of Vinal Haven and, while exhibiting few types, they are of peculiar petrographic interest and beauty. They furnish another illustration of the preservation, in ancient devitrified acid lavas, of the structures found in modern rhyolites and obsidians. They include taxitic and spherulitic aporhyolites, with flow breccias and tuffs of the same type. The spherulites vary in size from a pin-head to spheres several inches in diameter. No lithophysæ were found. The matrix in which the spherulites occur is cryptocrystalline and occasionally vesicular. The presence of perlitic cracks is taken as an indication that the crystallization is, in part at least, the result of devitrification of an originally glassy matrix.

The flow breccias illustrate still more strikingly the original character of a glass and in one instance, at least, subsequent devitrification has been very slight. This occurrence of glass in such ancient lavas is unique.

The succession for the acid volcanics is tuffs, taxitic aporhyolites, spherulitic aporhyolites, flow breccias and tuffs. The author deems that the eruption began before that of the Thoroughfare volcanics had concluded, and was from a different though neighboring vent.

In addition to the formations already described, there are great intrusive masses of granites and diabases, besides numerous dykes of quartz-porphyry and diabase. These intrusive, holo-crystalline rocks constitute the larger part of Vinal Haven. The ease with which the granite can be quarried and worked, the fine polish which it takes, and the proximity of the quarries to good harbors have rendered this rock of very considerable economic importance. The Vinal Haven quarries are said to be the most extensive in operation in America. Petrographically the rock is a typical biotite-granite with porphyritic facies. It is free from basic segregations, but contains numerous aplitic veins, which are considered by the author igneous injections subsequent to the consolidation of the granite. Associated with this true granite is a "black granite" which proves to be olivine-diabase and diorite. These basic intrusives are older than the granite which cuts the diabase in numerous sheets and dykes. The quartz-porphyry and diabase dykes are doubtless connected genetically with the corresponding acid and basic massive intrusives.

The time of the intrusion is conjectural. The dyke relations show the intrusives to be younger than the formations previously discussed. The plutonic conditions of the granitic crystallization necessitate a cover which has subsequently been removed. Time must also be allowed for the diabasic intrusion with its thinner cover. Hence a considerable interval must separate these intrusives from Niagara time.

The *alteration* which the igneous rocks have undergone has been due to the action of both superficial and deep-seated forces, and is both structural and mineralogical. The former is seen only in the change of diabases to greenstone schists. The latter alteration is by far the more universal and important and is considered by the author to be more of the nature of weathering than true metamorphism. The results of this alteration may be covered by the processes of saussuritization, epidotization and chloritization.

It is questionable whether saussuritization (see Rosenbusch, Mikros. Physiog., 3rd ed., vol. II, p. 282) can be considered a process of weathering rather than of metamorphism. Undoubtedly dynamic metamorphism is not essential to this process, but may not a static metamorphism be distinguished from those processes of disintegration (weathering) whereby, by means of hydration or carbonatization, compounds less crystalline and more soluble than the original compounds are produced? Devitrification is a good example of a similar metamorphism where, as the author points out, dynamic action is not needed as an initiatory factor in the process.

Nomenclature. Under this caption the question of the terminology of the volcanics is discussed. (1) The acid volcanics are termed aporhyolites on the ground of being devitrified rhyolites. (2) The more basic volcanics are called andesites, on the ground of their similarity with the modern andesitic lavas.

It might be pointed out that as these andesites are described as possessing a groundmass "originally very glassy" they deserve in consistency the prefix apo as much as do the devitrified rhyolites. This, however, is not the serious difficulty with the term andesite, that it does not indicate the alteration subsequent to consolidation. Are these volcanics of andesitic composition? The analysis of what was considered the most basic type (p. 33) can scarcely be considered that of a normal andesite. The analysis is as follows:

SiO_2	63.25
TiO_2	Trace
Al_2O_3	14.89
Fe_2O_3	6.54
FeO	None
MgO	0.82
CaO	0.59
K_2O	4.78
Na_2O	4.47
P_2O_5	0.61
H_2O (by PbO)	2.67
CO_2	0.78
Loss by ignition not accounted for by H_2O and CO_2 and including small amounts of Cl and F of apatite	0.53
	99.93

The high alkali percentage and the extremely insignificant amount of lime present in the rock quite preclude the predominence of a basic feldspar. The lime is abnormally small even for an alkali feldspar rock. The amount of P_2O_5 (0.61) present in the analysis, demands, to form apatite 0.72 parts of CaO. Allowing for a reasonable amount of error the lime still falls short of what is necessary for the apatite and for the calcite mentioned by the author and indicated by the percentage of CO_2, if the CO_2 is all combined with CaO.

It was from the presence of this calcite that the basic character of the feldspar was inferred, but presumably the ferromagnesian constituents, which were described as normal hornblende or augite, contain lime, which might give rise to some of the calcite. Both this analysis and that of the aporhyolite (p. 51) indicate anorthoclase as the predominating feldspar. In the other types described as andesites the feldspars are said to have the extinction angle of labradorite approaching andesine, of labradorite and of basic andesine. In these cases the test of analysis has not been applied, but in the single case where an analysis was made the composition seems to be that of a trachytic rather than an andesitic lava.

(3) The lavas with a porphyritic structure are termed *porphyries*, whether acid or basic. Thus porphyry becomes a term merely indica-

tive of structure and porphyrite is abandoned altogether. Although this usage is advocated by the leading American petrographers, it seems to the reviewer to lose in precision what it gains in simplicity.

Dr. Smith closes his dissertation with a comprehensive sketch of the geologic history of these islands. Along the border of the Arcadian trough of sedimentation volcanic outbreaks might be expected and the presence of ancient volcanics along the Atlantic coast has been recorded. Fox islands swell the list of localities for these volcanics. Pre-Niagara volcanic activity, giving rise to the North Haven greenstones, was followed by Niagara sedimentation. Subsequent to this, and even within Niagara time, vulcanism was again active when the porphyrites, and later, the acid volcanics were erupted. The history closes with the Devonian intrusion of the granitic, diabasic and dioritic masses.

Six photomicrographs, illustrating excellently some typical microstructures, and a geological map of Fox islands, based upon sheets 309 and 310 of the U. S. Coast and Geodetic Survey, accompany the thesis. This presentation of the results of a painstaking investigation is eminently readable, because of its clearness and freedom from confusing details, and thoroughly admirable in the judicial tone of its conclusions.

F. B.

Till frågan om fosforitlagrens uppträdande och förekomst i de geologiska formationerna, af Herman Hedström [Geol. fören, i Stockholm förhandl, Bd. 18, h. 7, pp. 560-620, 8vo. 5 figs. 1896]. In this article describing the appearance and the mode of occurrence of the phosphatic deposits in geological formations, we have the complement of that of J. Gunnar Andersson, issued a year earlier from the press of the University of Upsala. This article is professedly antagonistic to the earlier one, and sets forth Hedström's views on the origin of phosphates, with illustration from Swedish localities. The article is divided into six sections which we take up in order.

1. *On a conglomerate in the lower part of the glauconite limestone of the Siljan's Silurian.* [Siljan lake is in the Dal district of northern Sweden]. This section shows (based upon a weather surface of granite rock) a conglomerate bed about two feet thick with boulders of various clastics, and small nodules of phosphate. The rock also contains very sparingly distributed, examples of the brachiopod *Obolus apollonis*, near which the phosphate is apt to occur. Above the conglomerate is a thin bed (about 6 inches) of glauconite sand, supposed to be equivalent to the Ceratopyge limestone. The bed is about equally made up of glauconite grains and clay slate. No more than these two beds can be considered as Cambrian; the rest of the section is the Orthoceras limestone, at the base of the Ordovician—clayey in the lower part, but becoming more calcareous higher up. The lower (and probably the middle) Cambrian is absent from this section, and the phosphate nodules occur in both the glauconite sand and the limestone above, as well as in the conglomerate at the base. Hedström says there are distinct evidences that the glauconite and limestone beds transgress on the Obolus conglomerate, and that the phosphate in them may be derived from

the conglomerate. This is in support of the view everywhere expressed in the article that phosphate is a littoral formation.

2. *On chalcedony pebbles in glauconite limestone--Conglomerate at Sollerön.* The interest in these chalcedony pebbles rests on the fact that some of them contain micro-organisms, among which some are like foraminifera, others resemble bryozoans, etc., but the commonest are spicules of siliceous sponges; of the nature of these there is no question [figures are given of these, they are mostly hexactins]. Some of the fossils found he says are with certainty to be referred to *Monadites.** Herr Hedström appears to think that these chalcedony nodules did not originate in the bed where they are found, but have been derived from an older formation [Cambrian?] by erosion.

3. *On the occurence of phosphatic concretions in recent sediments.* In this is discussed the distinctions between shore deposits, shallow sea deposits and deep sea deposits; with many references to the work of the Challenger expedition, and of the depths at which phosphate bearing sediment had been met with.

4. *On the probable origin and building up of phosphatic layers.* The most common opinion on this point is that the mineral phosphate of lime is derived from organisms that secrete phosphorus. At the present time it may be derived from the bones of animals living on the land, or from the excrement of birds: or may be formed from marine organism, as bones of fishes, shells of crustaceans and brachiopods. Sea water now operates on similar remains rich in phosphorus more or less directly, so that the phosphoric acid is released and combines with iron or lime in the water. This material forms adhesive gelatinous drops, which have the same qualities as colloid bodies, namely to stick together and form concretions. Somewhat analogous (to the mode of growth of phosphate nodules as described by Dr. John Murray in the Challenger report on deep sea deposits) seems to be the mode of accumulation of the chalcedony nodules in the green limestone conglomerate of Dalarnia (described above); although the condition there has been yet more favorable because hydrated silica is even more a colloid body. After describing two methods by which phosphate nodules are produced, viz: the accumulation in a colloid form, and the replacing of carbonic acid in lime by phosphoric acid, Herr Hedström proceeds to speak of various sources of phosphates in later formations, and at the present time, and finally decides upon the shells of Inarticulate Brachiopoda as the chief source of phosphatic deposit in the early Cambrian. He gives many quotations from authors who have written on the subject of phosphate rocks, both of past geological ages and of the present time. Herr Hedström claims that all the original geological marine phosphate deposit have been formed in the littoral zone, giving the following reasons: (a) They occur with coarse sediment, conglomerate, gravel and sand. (b) That phenomena sometimes accompany the de-

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* In this connection he quotes W. D. Matthew--On phosphate nodules from the Cambrian of southern New Brunswick. Trans. N. York Acad. Sci. vol. XII, 1892-3, p.112-114, who also describes chalcedony nodules p. 108.

posit indicating that it was formed at the margin of the sea, or on land. (c) The nodules of phosphate commonly rest on the surface of an underlying bed [formation?] etc. (d) The occurence in the phosphate layer of fossils from other and older formations. (e) The appearance of the phosphatic layers in company with terrestrial or littoral organisms, etc.

5. *On the occurrence of phosphates at the boundary between the Cambrian and Lower Silurian in Neriko and West Gotland.* Herr. J. G. Andersson in describing these deposits stated that they were formed in a shallow sea, and that the phosphate was obtained from the underlying Peltura bed by chemical corrosion of the bituminous limestones in this shallow sea. Herr. Hedström combats this view, referring these phosphates, as in the other case, to erosion of the beds on a sea shore. This author differs also from Andersson on the conditions under which glauconite was accumlated with phosphate deposits, and contends that it was not formed in a shallow sea, but along shores, quoting occurences of this substance noted during the voyage of the Challenger, etc. The facts known however hardly seem to support this view. The author however remarks that studies of the marine deposits of the littoral regions have not been made with the same thoroughness as those of the deeper seas.

6. *Remarks on changes of level in Cambrian and Silurian times.* The author claims proof of such changes of level from the corrosion of the *Limbatus* limestone in East Gotland: from the fact that the Orthoceras limestones are conglomeritic in some places, the way in which parts [only] of thin shelled fossils of this limestone are preserved; from the way in which its cephalopods are heaped together, etc.: and also the alternating of littoral and deep water sediments.

Various other points in relation to corrosion holes in the limestones, are discussed, and it is well for those interested in the study of phosphatic and glauconitic deposits to read this paper in connection with J. Gunnar Andersson's of 1895, reviewed in this journal in February last. Both articles are based on practical studies of Cambrian and Ordovician terranes in Sweden. G. F. M.

Tables for the Determination of Minerals by physical properties ascertainable with the aid of a few field instruments. By PERSIFOR FRAZER. (4th edition, xii and 163 pp.: Philadelphia, J. B. Lippincott Co., 1897.) These tables are based on the system of Prof. Dr. Albin Weisbach, but in each edition, and especially in this, Dr. Frazer has made such changes and additions as the state of the science of mineralogy would warrant and such as would best adapt the tables to the use of Americans. As indicated by the title, the book lays no claim to an extended treatise on minerals, but it does claim, and that with justice, to furnish an aid to the ready determination of minerals by the use of a few simple instruments. The characteristics depended on are lustre, color, streak, hardness, tenacity, crystal system, habit, structure, cleavage and fracture; and to these are added chemical formulæ and remarks.

the latter including specific gravity, simple reactions and associated minerals. The tables are arranged in the form of a key, showing (1) minerals of metallic lustre, which are further divided according to color, (2) minerals of sub-metallic and non-metallic lustre, divided further as to color of streak, and (3) minerals of non-metallic lustre and white or gray streak, divided further according to hardness. Following the tables is a supplement with the various minerals arranged in alphabetical order, accompanied by their chief physical characters. A historical table of elements, scales of hardness and fusibility, and a very complete index finish the book.

The above outline of the scope and plan of this book is sufficient to show its useful character and its adaptability to the general student, prospector or amateur, and also to the geologist who wants a ready and simple means of determining minerals in the field. The fact that these tables have reached their fourth edition shows that they are appreciated and widely used, and the improvements in this last edition bespeak for it a much wider use. U. S. G.

Geologic Atlas of the United States. Yellowstone National Park Folio, Wyoming, 1896. A general description introductory to the map sheets is given by Arnold Hague, treating of the geography, topography, and general geology. An outline of the characters and occurrence of the sedimentary rocks is presented by Walter Harvey Weed, and a similar chapter on the igneous rocks by Joseph Paxon Iddings. Three sheets of illustrations showing characteristic scenic, geologic, and topographic features, serve as a further introduction to the maps. The atlas sheets are eight in number, four being devoted to the representation of topography with contour intervals of one hundred feet, and four to detailed areal geology. The scale is 1-125,000. C. E. B.

CORRESPONDENCE.

An explanation by Dr. Grimsley. Some criticism has been made on the article on the subject of Metamorphism in the January Geologist, because due credit was not given the late Dr. G. H. Williams for the classification of metamorphic processes and the definition of the word gneiss. The definition of this last word was given by me in a former paper on the granites of Maryland, at the suggestion and with the full consent of Dr. Williams. The classification of processes was one used by him in his lectures, and while it is always a pleasure for the writer to yield homage to the memory and influence of that inspiring teacher, it seemed to him unnecessary in the present instance to reaffirm this. The object of the article was to give in a popular style some insight into a difficult subject and to correct the improper use of certain terms among many of our science teachers. As the article was in no way intended as an original contribution to knowledge, it was deemed best to omit all references to authorities. G. P. Grimsley.

Topeka, Kansas, Feb. 1, 1897.

PERSONAL AND SCIENTIFIC NEWS.

Joseph Ewing MacFarland died in Baltimore, Md., Jan. 23d. He was connected with the U. S. Geological Survey and had been doing field work in Tennessee.

The Journal of School Geography is the name of a new publication edited by Prof. R. E. Dodge, of the Teachers' College, New York city, assisted by Messrs. W. M. Davis, C. W. Hayes, H. B. Kümmell, F. M. McMurry and R. deC. Ward. It is published at 41 Queen St., Lancaster, Pa.

Dr. G. F. Becker's paper on "*The determination of feldspars under the microscope by the methods of Michel-Lévy*," which was presented before the Geological Society of Washington Feb. 26, 1896, is to be published in the report on the geology of Alaska in the 18th annual report of the U. S. Geological Survey.

The Geological Society of London has made its awards for this year as follows: Wollaston medal, W. H. Hudleston; Murchison medal and part of fund, H. B. Woodward; Lyell medal and part of fund, G. J. Hinde; Bigsby medal, Clement Reid; Wollaston fund, F. A. Bather; balance of Murchison fund, S. S. Buckman; balance of Lyell fund, Joseph Lomas and W. J. Lewis Abbott.

Prof. Johann Auguste Streng died at Giessen on Jan. 9th. He was well known for his work in mineralogy and chemistry, and from 1867 to 1895 occupied the chair of mineralogy at the University of Giessen. It 1877 he published in the *Neues Jahrbuch*, in connection with J. H. Kloos, an extensive paper on the crystalline rocks of Minnesota. Later this paper was translated and printed in the 11th annual report of the Geological and Natural History Survey of Minnesota.

Sir Archibald Geikie will deliver six lectures on the principles of geology at the Johns Hopkins University, April 21st to 27th. The lectures will be given in the geological laboratory at 5 p. m., and a public lecture will be given on the evening of April 27th. This lectureship is established in memory of the late Prof. G. H. Williams. After the lectures arrangements have been made for a four days' excursion (April 28th to May 1st). The typical geological localities of Maryland will be visited and an opportunity will be afforded to examine the several formations of the Coastal plain, the Piedmont plateau and the Appalachian region. Special rates will be given by the transportation companies to such geologists as may desire to go.

NEW YORK ACADEMY OF SCIENCES.

The Geological Section met Jan. 18 and listened to the papers, of which abstracts are given below. Both will appear in full in the Transactions.

J. J. STEVENSON. "Notes on the Geology of the Bermudas." After describing the several types of rock deposits and their relations, as well as the surface features of the area, Prof. Stevenson offered the following conclusions respecting the successive conditions:

First: The limestone, or "base rock" of the island, was formed by accumulation of dune sand. During a prolonged period of quiet, the rock underwent great erosion, both surface and subterranean; the collapsing of cavern roofs caused great "sinks," some of which, no doubt, still exist as such, though to distinguish them from those of later origin would be difficult.

Second: A period of subsidence followed, during which the land sank 120 feet or more. Marine deposits encroached upon the land, intruding inland through valleys, thus giving beach rock at widely separated localities and in somewhat anomalous positions.

Third: Succeeding this was a period of quiet, during which the sandstone was formed, as the limestone had been, by accumulation of dune sand, and the great "sinks" were filled up, as the basins of Castle harbor are now filling.

Fourth: A period of elevation followed, during which the land must have risen to at least its former level. The old subterranean drainage systems must have been re-established in many instances, and the former depressions cleaned out, while new systems may have been formed, causing new groups of depressions.

Fifth: This was succeeded by a period of subsidence, during which the land sank to very nearly the same position as at the maximum of subsidence in the previous period, the highest marine beds being now only a few feet above the water's edge. The more important bodies of water began in the deeper depressions, early in the period, but they assumed their present forms, due to shore erosion, only in the later portion, when the subsidence was very slow, and evidently interrupted more than once by prolonged periods of quiet. The paper was illustrated by the lantern.

ARTHUR HOLLICK. "The Geological Section at Cliffwood, N. J."

Mr. Hollick described the Cretaceous clay marl in the vicinity of Cliffwood, New Jersey, one of the localities where the fauna of the horizon has been collected and the only one at which any fossil plants have been found.

The strata in question are the equivalent of the Matawan formation of Prof. W. B. Clark, which represents the transition from the plastic clays of the Raritan formation below to the greensand marl above, and, as may be expected, shows a commingling of fresh water, land and marine conditions. The specimens collected consist of crustaceans, leaves, fruit and twigs of trees and masses of lignite. The crustaceans are too fragmentary for exact determination. About 15 species of mollusks were identified and 26 species of plants, the majority of the latter belonging to the Coniferæ. Of these, nine are here described as new species. The paper was illustrated by maps of the region, drawings of the specimens and the specimens themselves. J. F. KEMP, *Secretary.*

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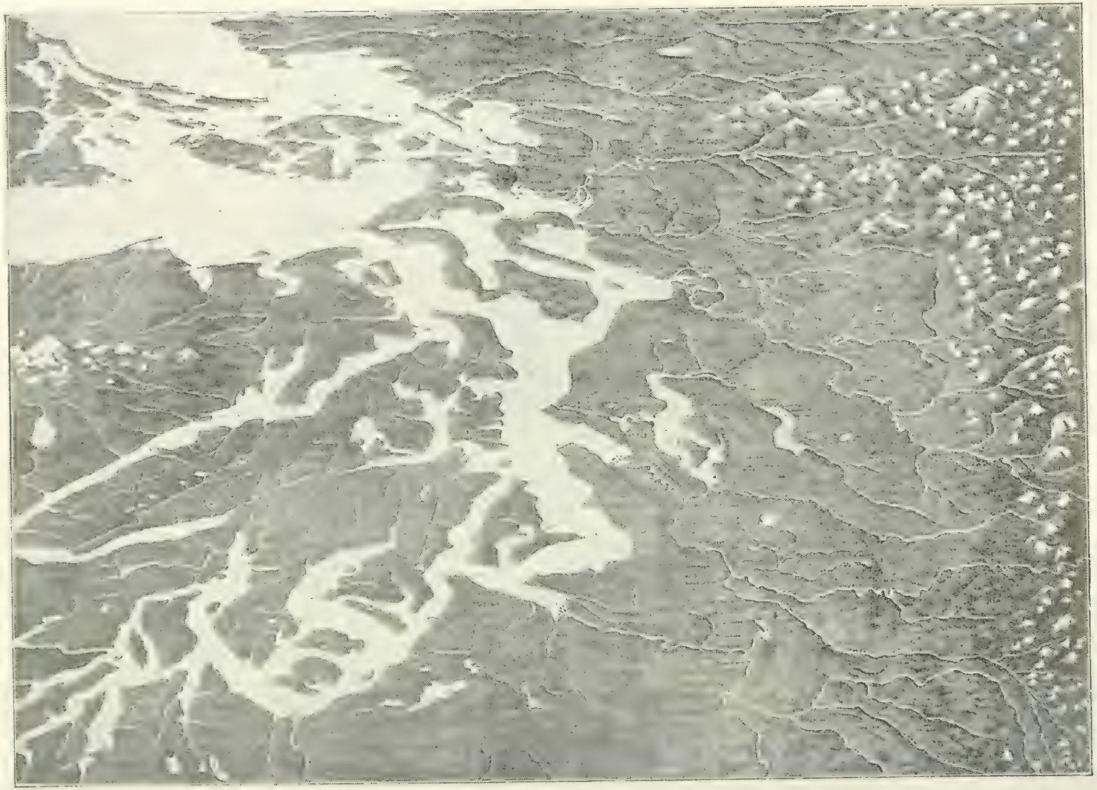

HYDROGRAPHIC (Birds-eye) SKETCH OF PUGET SOUND.

UNIVERSITY of ILLINOIS.

THE

AMERICAN GEOLOGIST.

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PHYSIOGRAPIC GEOLOGY OF THE PUGET SOUND BASIN.

By James P. Kimball, New York.

Plate XII.

I.

The discovery in Douglass county, Oregon, of unconformity between beds of the Shasta-Chico group and overlying marine Tejon strata serves to denote more or less of a physical break between the Cretaceous and Eocene on the Pacific border.* Extension of the post-Cretaceous or post-Laramie elevation is thus indicated, as well as correlation of the Tejon with the Eocene. No similar contact unconformity in the Puget Sound basin has yet been brought to light. The upheaval, as a rule, of the productive lignitic series on the flanks of massive eruptives in the elevated border of the basin, militates against the occurrence of undisturbed unconformities. A single basal unconformity of that series, with ancient crystalline schists on the Skagit, is noted by Willis,† but with no certainty as to whether due to original deposition or to faulting. The less elevated and less disturbed marginal developments of

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*J. S. Diller and W. Stanton, Bull. Geol. Soc. Am., V, 1894, p. 643. S. F. Emmons, *ibid.* I, p. 285. Marsh, Am. Jour. Sci., 4th Ser., II, 1896, p. 439.

†Report Tenth Census, XV, p. 759.

sound. From the clearest evidence of increased elevation of insular, and partially insulated areas, where effects of erosion due to changes of level are the more obvious—as in raised sea beaches and shell beds, and, again, from redemption of delta deposits—it will finally be shown (8) that partial emergence incidental to re-elevation has taken place during comparatively recent periods.

It will also appear that the origin of certain great fresh-water basins on the eastern border of the sound was in common with that of the present tideways, as above indicated, and that they have been cut off from the maritime basin by participation in the moderate re-elevation already noted—probably the last of the series of important regional oscillations of level.

The only survivals from baseleveling erosion which have come to my knowledge are several outcrops within the outer border of the sound, as above limited and defined, and mainly connected with what I may designate as the Restoration Point uplift of the Tejon formation.

As far as I am aware, and as also stated by Dr. White, but a single outcrop of that formation has hitherto been made known to geologists.* This is an old quarry in soft, partly fossiliferous sandstone, known by Dr. White as Fossil bluff, near the mouth of the Duwamish river, at South Seattle. A number of marine molluscan fossils labeled as from this locality, in the possession of the Smithsonian Institution (Blatte collection) are referred by Dr. White to the Tejon epoch in common with all the Eocene strata recognized as such in Oregon. A collection of fossils and of fragmental vegetable products from the same locality was obtained by me in the year 1894. A much more prolific fossiliferous occurrence of the same formation will be indicated later on.†

Non-fossiliferous parts of the same formation, under a high dip to the northeast, are exposed at intervals for nearly a mile to the south, in the east bluff of the Duwamish valley, as far as Georgetown (Duwamish). In the same bluff, just above that suburban village, these strata give way to volcanic rock. To this particular occurrence reference will presently be made. The contact appears to be in the bed of a small cascade in the bluff back of the Martin place—a locality requiring some excavations for further investigation with reference to this point.

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*Bull. U. S. G. S., No. 51, p. 31.

†The labels of the " Blatte collection " instead of implying two separate localities twelve miles apart, as inferred by Dr. White, doubtless refer to the single conspicuous outcrop noted above. No lake in the region is known as Duwamish. (See Bull. U. S. G. S, No. 51, p. 30; No. 83, p. 106.)

Two miles south of Fossil bluff, on the opposite side of the river, at South Park, two prominent outlying survivals of the same formation are seen, one on the Puyallup road, and the other forming the eminence on which stands the Catholic college.

Other isolated survivals rise above the drift in the vicinity of lake Washington, one just north of Columbia, and the other just north of Brighton beach, at the water's edge. At the latter point it occurs as usual, under a high northeast dip, and contains a seam of lignite of inferior quality. Remnants of the same formation are said also to be present at the point of the opposite island (Mercur).

A much more considerable survival of the same formation is a baseleveled tabular surface, about five feet above tide, at Alki point (Battery point). Here again, as in the Duwamish valley, the formation is nearly on edge at the extreme point, and for some distance along the beach to the south, but flattening out in that direction and gradually disappearing below tide. The marginal plateau has been denuded of all but a thin mantle of drift for several acres around the point by the action of the waves, at a former stage of somewhat lower elevation, the degree of which is more exactly indicated on the opposite shore of the sound. Beneath the sod, as far as the rock could be stripped without implements, the surface is hard and smooth, but whether ice-scratched or not remains to be determined. Just back of the solid margin, at the point, drift bluffs rise to a hight of 400 feet. No other basal rocks appear above tide beneath the drift headlands of the West Seattle peninsula.

The occurrence of the same formation at Restoration point, on the opposite shore of the sound, is the most prominent survival of solid basal rock within the limits of the marine basin. Along the shores of the peninsula terminated by that point, sound. From the clearest evidence of increased elevation of insular, and partially insulated areas, where effects of erosion due to changes of level are the more obvious—as in raised sea beaches and shell beds, and, again, from redemption of delta deposits—it will finally be shown (8) that partial emergence incidental to re-elevation has taken place during comparatively recent periods.

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The occurrence of the same formation at Restoration point, on the opposite shore of the sound, is the most prominent survival of solid basal rock within the limits of the marine basin. Along the shores of the peninsula terminated by that point, baseleveled basset edges of the whole sandstone series form a marginal plateau, some 15 feet above tide, like the tabular eroded surface at Alki point. Thus a low escarpment, four or five times higher than at that point, is continuously presented back of the beach as a natural sea wall, all the way round the point from Blakely harbor to Rich's passage. Back of the marginal plateau, the same formation rises in mural cliffs, some 300 feet. A complete section of some 3,000 feet across the strike is finely exhibited along the beach. The strike and dip of the whole series (Tejon) are uniform on both shores of the sound, the main channel having been eroded directly across the upturned belt.

This belt, as a whole is characterized by soft, heavy-bedded grey sandstone, occasionally fossiliferous and carbonaceous, alternating with shaly, non-fossiliferous members, fissile, soft and highly frangible, and exhibiting a conchoidal fracture. Weathered surfaces are crimson and brightly variegated. A highly fossiliferous member is a conspicuous feature at the extremity of Restoration point (Decatur reef). Like the fossiliferous bed at Fossil bluff, this is also, but less extensively, flecked with fragments of carbonized vegetable products. The two occurrences are lithologically similar. On the Blakely harbor shore, at the upper landing, a bed of lignite from two to three feet in thickness is exposed at low tide. Massive fragments from ablation of this seam are deeply imbedded in a raised beach. A seam of lignite is said, likewise, to occur below tide south of Alki point. A similar occurrence at Brighton beach has already been noted. This, like the fossiliferous member, probably marks a distinct horizon at the several points mentioned.

Mention may now be made of the interesting circumstance that the solid structure as presented in the promontory of Restoration point is limited to that once insulated area. As a comparatively recent event, this area has so far been re-elevated as to connect its base with the main island (Bainbridge). This is strikingly indicated not only by complete erosion of the sandstone series directly across the strike from the head of Blakely harbor, and its replacement by alluvial material, but also by the raised beach which is a part of such replacement. This occurrence is well exhibited by extensive clam beds six to twelve feet above tide and two and one-half feet below the top of the marginal plateau, and uncovered in the gullies as far back as 100 feet inland. The same beds are clearly exposed along shore in the bank for several hundred feet. Though extremely fragile, the shells are whole, and in a state of perfect preservation. The present beach is white with their fragments. Two species are identified by Prof. Whitfield as follows: *Saxidomus giganteus* (Deshayes), a Pleistocene form still existing on the Pacific coast; and *Saxidomus rigidus* (Gould), occurring at Santa Barbara in raised beaches, and also a living form.

Considering the habitat of these bivalves, along with the uniformity in hight of the baseleveled margin, and its alluvial extension on opposite sides of the original islet, the measure of regional re-elevation locally indicated may be estimated as not less than 25 feet. Behind the solid promontory, as remains to be explained, a low eroded alluvial surface, at about the level of the sea margin, is followed by the carriage road to Rich's passage. The same depression doubtless represents a level which, in common with the ancient clam beds, was submerged antecedent to elevation. A single baseleveled outcrop of the sandstone is obscurely seen in the road. Rich's passage, like the main channel of the sound, is excavated directly across the Tejon uplift.

The peculiar configuration of the baseleveled marginal plateaus, so characteristic of the topography, terminated by the few rocky points on opposite shores of the sound, and of all littoral survivals of that uplift, is, in the light of the above evidence of post-Glacial re-elevation, readily explained.

The Restoration point uplift crosses the Point Glover peninsula under uniform topographical conditions implying baseleveling erosion and subsequent re-elevation. Here, however, it is seen to rise on the flank of an eruptive belt which likewise crosses the peninsula from a point opposite Nibbeville (Port White) with the same strike as the sandstone series—in line, that is, with Restoration and Alki points. While the northern contact of the intrusive belt, following a plane of stratification, is very sharply defined, the southern contact, for lack of opportunity, was not traced so as to determine the breadth of the belt. This can readily be done by examination of the shores of Orchard point. On the north shore, as I am informed by Mr. F. H. Whitworth of Seattle, the same eruptive belt is well exposed to a hight of over 100 feet, maintaining the same prominence as at Rich's passage.

The lithological composition and physical construction of the dyke as exhibited within compass of the quarry are extremely varied. The bulk of the mass may be described as a greenish hornblendic aggregate, granular and spherulitic, and in certain distinct divisions partially brecciated, and crumbling on weathered surfaces. Aphanitic material in schistose form constitutes other distinct divisions. Olivine, likewise present, is not without significance in connection with the volcanic origin of the mass.

The formation developed south of Georgetown on the Duwamish, is of the same lithological type and divisional constitution, and is doubtless a survival of the same eruptive belt, to the extension of which is to be ascribed the upheaval of the Tejon series. In tracing that survival to the southeast. I shall take further occasion to refer to its advanced decay from weathering.

On the north side of Blakely harbor, cemented gravel or conglomerate, made up of pebbles of crystalline rock, occupies the low shores on both sides of Blakely point. Blakely rock, at the entrance of the harbor, is a survival of the same cemented gravel—otherwise practically baseleveled and preserved above tide only in isolated masses in place. Divisional planes and courses of differentiated material serve to indicate a thickness of several hundred feet with strike and dip conformable to the underlying Tejon series on the opposite side of the harbor. Hence the inference that the cemented gravel was upturned on the flanks of that series. A few hundred feet north of Blakely point the cemented gravel gives way to drift.

The aspect of the rock which sets in just south of Georgetown is casually that of a greenish, pebbly, clastic aggregate, cemented by similar material of finer consistency. This appearance, however, is deceptive. Kaolinization and peroxidation of feldspathic and ferrous silicated contents respectively have resulted in almost complete disintegration of weathered surfaces. A key to the normal condition of the mass under cover is afforded by a ledge obliquely crossing the plank road from the point where it makes its first appearance in the bluff. Thanks to Mr. R. H. Thompson, city engineer of Seattle, the ledge which had been graded off was laid bare for my examination. As at Point Glover, it is there seen to possess a divisional structure. A narrow zone of sound rock thus visible is characterized by a porcellanic magma mottled with spherulites. These differentiate in weathering. Hence the pebbly aspect as seen in the bluff. Certain decomposed divisional parts under cover are extremely cellular and quite unlike anything seen in the bluff, but of similar type to certain parts of the Point Glover belt. While the eruptive character of this ledge is pronounced, the pebbly, and in part brecciated, material first described is with difficulty identified, macroscopically at least, as of similar character. By gradation, however, it may be traced into sound rock in a quarry at Cardmore, through a number of intervening outcrops in the bluff, which in that direction is broken into hills. Above Cardmore the same rock is preserved in prominences on both sides of the Duwamish. The identity of this belt with that of Point Glover has already been indicated on grounds of uniform relations, strike, lithological character, and divisional constitution. This occurrence has been described in some detail because it differs extremely from all other eruptive products which have come to my notice in the elevated border of the sound. These are generally of the types of diabase and basalt.

According to Mr. Thompson, Wing point on Eagle harbor (Bainbridge island) is of solid formation. Basaltic survivals are reported by Mr. Whitworth at the head of Sinclair inlet, and again about midway of the north township line to the west (R 1 E., T. 23), and also directly to the north on the next township line. Hood's canal at the base of the Olympics is well known to be bordered on the west by a long stretch of basaltic rock between Lilliwaup river and Quilcene bay. Similar rock is said to be exposed at Dewatto bay on the east shore of the same inlet, and again at Hood's head.

At Volcano point, Double bluff, as I am informed by Mr. Whitworth, a series of soft sandstones is exposed near tide. Imbedded in a seam of lignite within this series were found several years ago, according to this observer, vertebrate remains, said to be of a mastodon,—thus, as far as the evidence goes, indicating Pliocene relations. Rocky soundings noted on the Coast Survey chart No. 6,450, between this locality and Foul Weather bluff, probably indicate eroded surfaces of the same strata. Invertebrate fossils are reported by Mr. Eugene Ricksecker, of the Lake Union, etc. Ship-canal survey (U. S.) on Dogfish bay, Orchard inlet. An isolated body of coralline cement (limestone) surrounded by drift is said to occur 12 miles up the Puyallup valley at a point known as Lime Kiln, and so designated on maps. Such a survival may not be without significance in connection with the Tejon uplift on the same line.*

Outcrops of solid rock here described, together with reported occurrences as above noted, are the only survivals of which I have been able to learn within the generally baseleveled area embraced by the marine basin of the sound; south, that is, of the basaltic development forming the border of Deception passage. All other land surfaces, so far as I am aware, including the immediate border of the sound, are wholly covered with glacial drift of great thickness.

The distribution of baseleveled and eroded surfaces below tide, especially in the lower part of Admiralty inlet, is indicated by the Coast Survey charts.

Covering a considerable part of the state of Washington, embraced by no other publication of the kind, the general geologic map prepared by the Geological Survey of Canada from surveys made from 1842 to 1882, indicates the shores of Puget sound, as well as the wide expanse embraced by the lower part of the Columbia basin, as sedimentary Miocene.

As to the Puget sound basin, this appears to have been on the evidence of earlier determinations by Newberry, Lesquereux and Heer, of several collections of fossil flora from carbonaceous strata on Bellingham bay and vicinity, which although sometimes still referred to the Miocene, are probably undistinguishable from the Chico portion of the Upper Cretaceous, or the Puget group of White.* Reference of strata of the lower Columbia basin to the Miocene remains unquestioned. Marine Miocene is identified on Willapa bay.

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*Occurrences of Aucella at Seattle, and also on Vashon island in fragmental blocks, as reported by Mr. Diller, were for obvious reasons doubtless erratic. An occurrence in place on the Skagit, B. C., is reported by Dr. Dawson.

Diller: Bull. Geol. Soc. Am., iv, p. 217.

Dawson: Desc. Sketch, p. 51.

The same extensive area south of the 50th parallel is broadly denoted by Dr. White as a Cretaceous margin of the Cascades so as to compass the outer limits of known isolated survivals of the Coal series, as well as the drift area, but on too minute a scale to distinguish the Tejon series, an outcrop of which at a single point only had already been identified by this authority by means of the Blatte collection of fossils.

Survivals of sedimentary formations and eruptives beyond the immediate border of the sound, and also in eroded channels east of lake Washington, in the foot-hills of the Cascades, cannot here be detailed.

In the divide between lakes Washington and Samamish, the Gilman monoclinal coal series is uplifted on the north flank of an intrusive mass. Several other uplifts, presumably of the same series, are exposed to the eastward on the waters of Snoqualmie river, together with bold massifs and lesser prominences of eruptive rock. In the divide between Cedar and Black rivers, near Renton, occurs an expanse of coal-bearing strata, a deformed and eroded surface of which as above noted is overflowed by volcanic material in bedded form, and lithologically identical with the spherultic intrusions on the Duwamish, and probably a part of that plutonic development. The schistosity of the overflow produces a striking semblance of a sedimentary unconformity. Farther toward the southeast are developed several uplifts of coal-bearing strata, mostly monoclinal, constituting the well-known coal areas of upper Cedar and Green rivers, together, in most cases, with the usual basal accompaniment of eruptive bodies. These, however, are beyond, and at considerable elevations above, the sound, and therefore call for no description in the present place.

Renton is on the edge of the immediate solid border of the marine basin and the point at which the Tejon uplift is recognized nearest the productive coal series, namely, at Brighton beach. The locality is at the lower end of lake Washington, in the fork of Cedar and Black rivers, the latter flowing into the Duwamish and uniting the overflow of the lake with the waters of the former. Above the junction of Black river the Duwamish takes the name of White river, which heads in the glaciers of Mt. Ranier.

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*Bull. U. S. G. S., No. 84, p. 231; No. 82, p. 197.

Collections by geologists as follows: Geo. Gibbs (Boundary Commission); J. D. Dana (Wilkes Exploring Expedition); John Evans (U. S. G. S., Territory of Oregon).

On the south side of Cedar river cañon, eroded from the solid table land, the old Renton colliery was opened near the mouth of that river. On the opposite or west side of the same subordinate watershed was opened the Renton-Talbot colliery, and on the southern slope that of the present Renton-Co-operative Co. The following is a section of the Coal series under a dip of 16° to the east and a strike nearly at right angles to that of the Tejon series at Brighton beach (N. 22° E.) between which point and Renton there thus appears the probability of unconformity of the two series.

1.	Upper barren shales and sandstones of which an eroded and channeled surface of basset edges is uniformly overflowed with schistose eruptive. This is in an advanced state of disintegration from weathering......	500+ ft.
2.	Coal No. 1 ("Old Renton colliery")...................	14-16 ft.
3.	Shale, slate and sandstone............................	30 ft.
4.	Shaly fossiliferous sandstone (bivalves)................	2½ ft.
5.	Shaly fossiliferous sandstone with leaf impressions	5 ft.
*6.	Coal No. 2 ("Old Renton colliery")	8-10 ft.
7.	Shale and micaceous sandstone......................	62 ft.
8.	Coal No. 3, Renton (Talbot, and Co-operative Co.).....	11-14 ft.
9.	Coarse grey sandstone, air-slacking, with three thin seams of lignite, as shown by boring.................	500 ft.

On the opposite bank of Cedar river, around on the slope which rises from the lake to the Newcastle plateau, edges of lignite-bearing strata are nearly horizontally presented half way up the slope. The actual dip, however, is concealed. Whatever this may be, unconformity with the Renton series is here again conclusively implied.

The discovery and definition, as above set forth, of an important separate development of marine Tejon (Eocene) strata, only slightly carbonaceous, as well as of inferential or constructive unconformity with the productive lignite series of

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*In seam No. 2 was found, lengthwise of the gangway, the stump of an immense tree in progressive stages of alteration from comparatively sound bark and woody fibre toward the butt to silicified products only slightly bituminized toward the smaller end. This occurrence is described by Mr. Whitworth, who furnished the above section, as undistinguishable from the existing species of native cedar.

the Puget sound border, tends to negative the theory which assigns that series to a relation transitional between the Mesozoic and Cenozoic formations. On structural grounds at least, its upper limit seems to be no higher than the Chico or superior portion of the Upper Cretaceous of the southern Pacific border, in common with that of the Carbonaceous series of eastern Vancouver and the strait of Georgia.

(*To be continued.*)

ESKERS INDICATING STAGES OF GLACIAL RECESSION IN THE KANSAN EPOCH IN NORTHERN ILLINOIS.

By Oscar H. Hershey, Freeport, Ill.

(*Continued from page 209.*)

Now, while the evidence clearly proves that the esker material was not gathered from the till of the vicinity, it may be claimed that it was derived from englacial local drift which was carried up into the body of the ice at some distance east of this district, and which, by the ablation of the peripheral portion of the ice-sheet, became superglacial and was swept into the streams flowing over the ice. This hypothesis, however, is effectually disposed of by a study of the englacial drift of the district. On the south side of the Pecatonica valley, east of Ridott, certain high flat-topped ridges have had their residuary clay and chert abraded from them, but the ice failed to deposit its ground moraine over them. Upon the final abandonment of the region, all the englacial material which the ice contained over any given spot must have settled down upon these ridges of bare rock. The finer portion of this englacial material was largely removed by subsequent subaerial erosion, but all the pebbles and boulders over one inch in diameter must still remain on these ridges. Some of these areas of nearly bare rock cover several square miles, and we find scattered over them a small amount of well rounded foreign material and a few erratics of boulder size. Over the gravel beds and over the till or ground moraine of the entire district these scattered boulders are found in about the same proportion as over the ridges of nearly bare rock, besides a small amount of pebbles of lesser size. We are thus able to determine, with a tolerable degree of certainty, the following facts about this englacial and superglacial drift: 1. Its total amount (excluding clay and fine sand which have been largely removed by subsequent erosion) would not make a uniform layer over the entire district exceeding one inch in thickness. To remove all element of uncertainty in the statement, I will replace it by five inches. 2. Among this material exceeding one inch in diameter, Galena limestone does not make up a tenth part of one per cent. During several years' residence in this district, and in repeatedly traversing it, I have found several hundred erratics of Niagara limestone, but less than a score of boulders of Galena limestone, which could clearly be traced to the englacial drift.

Having satisfactorily determined that the greater portion of the coarser material in the esker ridges was derived neither from the englacial drift nor the ground moraine, but by direct erosion of the stream from the rock ridges, let us see to what this conclusion leads us. Some of the coarse gravel knolls reach an altitude greater than any hills within miles of them and overlook all the surrounding country. While this is not generally the case, there are quite a number of places where the origin of the coarse cobbles and small boulders can be determined with some certainty, and in a large proportion of these cases the gravel is now higher than the point from which it was eroded. In the case of the knolls containing Freeport gravel, it was probably raised to a hight of at least 90 feet, but we cannot tell in how short a distance this was accomplished. A careful study of the entire district, however, will convince anyone that the streams sometimes raised coarse gravel to a hight of 100 feet within two miles; or, to be within the limits of absolute certainty, we may reduce this to 25 feet per mile. Now it is obvious that the esker stream flowed with a strong current from the place where it eroded the material to the place of its deposition; and therefore, if in an ordinary channel, it flowed down grade. This would require a most remarkable amount of tilting of the district to account for the raising of the gravel. Were this a geologic province subject to profound orogenic movements, we might seriously entertain this hypothesis; but there is absolutely no correlative evidence of it. On the contrary, if we may judge by analogy with later glacial epochs, our district was at the time, if warped at all, tilted toward the northeast, instead of toward the southwest, as the phenomena of the gravel knolls would require.

Even if we were to consider it not fully proved that the material of the knolls has been carried to a greater hight than its original position, we have another way of determining that these streams eroded material from a lower level than their outlets. The ice occupying and completely filling the lower portion of the Pecatonica basin compelled the drainage to pass over the divide which separates it from the basins of Plum and Apple rivers. We cannot be mistaken in the direction of flow in the glacial streams, for it is obvious that this direction coincided with the trend of the esker ridges and belts, and it certainly was not against the direction of ice-movement or into the body of the glacier. The westward flow is further indicated by the manner in which the secondary belts join the main belts, in the prevailing westerly dip of the strata, and in the many cases where the origin of the coarse material can be traced to the east. Now the lowest point, at present known, on the above mentioned divide, is at least 125 feet higher than a point in the Pecatonica valley where a stream eroded material by the action of a strong current. Consequently, unless our knowledge of hydrostatics is entirely at fault, only two hypotheses can be advanced in explanation of the phenomena, namely, that the district was tilted strongly toward the west and southwest, or that the streams resulting from the melting of the ice "flowed up hill." As all the evidence negatives the idea of a tilting of the region, the latter hypothesis must be adopted, which, of course, implies that the stream channels were covered by ice—were, in fact, tunnels—and that the powerful force displayed by the currents which flowed in them was due to hydrostatic pressure. (This theory of the formation of eskers in other regions has long been before the geologic public, so that I am not taking new ground in applying it to the esker phenomena of northwestern Illinois.)

It is supposed that the surface of the ice-sheet, under the influence of a milder climate than that which formerly obtained in this region, melted freely to a distance perhaps fifty miles back from the margin. The streams thus formed flowed on the surface in deep channels until they encountered a crevasse or a moulin, when they descended to a position at or near to the base of the glacier, and thence they continued on their way to the border. This latter portion of the course was in a tunnel, which, near its western end, came down so low as to encounter the surface of rock ridges, and in at least one case reached deposits that probably lie buried under the present valley bottom. As the season progressed and melting increased, the tunnels were not large enough to freely carry off the drainage, which caused a ponding of the water in the crevasses of the ice at some distance from its border. The pressure of this ponded water forced the subglacial streams through the tunnels with great force, and their powerful currents eroded the rock ridges and other deposits which they encountered, sweeping them forward and suddenly dropping them at or near the mouth of the tunnel, where the pressure was removed. This is the groundwork of the theory, but many of the details remain to be filled in.

The deposition of the stratified gravel and sand beds belonged to the general recession of the ice-front, and rarely ever to its advance. Their interior shows that, except in very few cases, they were but little disturbed by the forward movement of the ice. The steepness of the knolls and ridges, demonstrably largely original, indicates that they were not generally overridden by it. They are an upper member of the drift-sheet, —one of the last deposits which the ice made before abandoning the district. The erratics which constituted the englacial drift are frequently found upon the esker ridges, or incorporated with the upper portion of their gravel, corroborating the idea that they were formed in channels arched over with ice. But, except in a few cases, these gravel ridges are not overlain by the ground moraine. One of the exceptional cases occurs four miles south of Freeport, where a prominent gravel knoll has been mantled with six feet of typical till, forming an elongated prominence with the distinctive drumloid topography. In a cutting on the Illinois Central railroad, two and a half miles southeast of Freeport, a wedge of the boulder clay or ground morraine passes into the side of a stratified gravel ridge, plainly indicating ice-movement during the formation of the ridge. Just enough of such evidence occurs to prove that the ice was in motion during the formation of the stratified drift, but not enough to prove that these deposits were generally overridden by it. Now, we cannot suppose that the tunnels remained intact and stationary throughout a distance of twenty or more miles while the ice continued to move forward. As the ice undoubtedly did move forward (most decisive evidence of this movement will be produced when I come to discuss the transported rock masses), and as also the deposits at the east end of the belt show no more evidence of disturbance than those at the west end. which is practically none, we may conclude that the ice-front progressively retreated eastward across the district, and that the deposits as now seen are only those which were laid down about the mouths of the tunnels. Thus the analogy between the systems of "belts" and a subaërial river system is more apparent than real. However, as the situation of the deposits was determined by the position of the tunnels, which position was partly dependent on the topography of the district glaciated, the belts as they now appear were outlined by the tunnels, and consequently we may judge of the courses of the subglacial streams by a study of the belts.

When the retreating ice-front halted for a time along some line, such halt being similar to those which, in a later glacial epoch, formed the terminal moraines, the deposits made at the mouths of the tunnels during a number of summers closely adjoined or overlaid each other, so as to form more prominent accumulations than when the mouths of the tunnels were in rapid recession. This is my explanation of the so-called "special areas" of these gravel deposits. Every one of them indicates a halt of some length in the recession of the ice-margin. In other words, they correspond to the kames, or short ridges of diagonally stratified gravel, which are often found in depressions or gaps in the terminal moraines.

Let us follow a given ridge, as, for example, one of the many which together constitute the Pecatonica belt, and study it in more detail than we have yet done. Traversing it from its eastern end, we see it gradually grow larger until, at one, two, or three miles from its point of beginning, it is suddenly developed into a "special area," and then just as suddenly it may die out completely. One of these short ridges constitutes the deposit of the single stage of the destruction of the glacier, while the "special area" indicates the position of the mouth of the tunnel.

I shall next attempt an explanation of another phenomenon connected with these stratified drift deposits, which has been observed in many other districts. It is that the beds of coarse gravel, cobbles, and small boulders, are almost invariably at the top of the deposit, contrary to what we usually find in the product of ordinary stream action. They cap the mounds in the "special areas," and, by protecting them from erosion, are largely responsible for the present topography. It is evident that some special cause must have operated in this case. This cause I would find in periodic changes of climate, such as are affecting the Alpine glaciers at the present time. The ice-front having remained nearly stationary during some years or possibly decades, very suddenly retreated to a distance of several miles. This sudden recession corresponded to a mild period or a series of warmer summers. Melting of the ice was excessive, and hydrostatic pressure very great, so that the streams, by their increase of power and lower position, due to the decay of the ice, rapidly eroded the rock ridges with which they came in contact, hurried the material forward, and hurled it over the banks of sand at their mouths. It was their last effort, for after a few seasons the ice-front had established a new terminal line, and a new series of "special areas" was formed, to be capped in turn by a thick stratum of coarse gravel. This hypothesis is, as far as I can see, the only one which will satisfactorily account for the persistent association of beds of coarse gravel with the upper portions of the deposits in the "special areas."

None of the ridges are terminated at the west end by a well marked delta plain or a gravel plateau, such as are common in some of the more eastern districts. The nearest approach to a delta is the sand plain which terminates the western end of the Pecatonica belt. But instead of sloping gradually from the end of the ridged deposit to the outer edge of the plain, it is simply a nearly flat bed of sand lying at the foot of a series of abruptly ended ridges. This abrupt westerly termination of the several ridges is characteristic of this district, and at first thought might seem to be a very puzzling phenomenon.

For it is difficult to understand how the streams, after leaving the tunnels, could have flowed down over these sometimes almost perpendicular slopes without destroying the ridges or carrying much material with them. This difficulty, however, disappears when we remember that all the deposits which we have been discussing occur in basins which, being open only toward the east, were at that time obstructed by ice, and quite naturally we should expect them to be occupied by extra-glacial lakes. The streams, on issuing from the tunnels, flowed into these lakes, immediately dropping their coarser material, but carrying their loess-like silt to a greater distance and spreading it over the lake bottom. That the existence of these lakes is not merely theoretical is proven by the deposits of one of them situated in the Yellow creek valley in western Stephenson county, Illinois, and the Pecatonica river valley in Green county, Wisconsin.*

The significance of these extra-glacial lakes lies not solely in the explanation of the abrupt western ends of the gravel ridges, but they strongly negative the supposition of a westward tilting of the district, and so their bearing on the "tunnel and hydrostatic pressure" question is of the greatest importance. This may be briefly stated as follows: Deposits of gravel were eroded by strong currents at a level of 100 feet or more below the surface of the lake into which these streams flowed, only a few miles distant. Hydrostatic pressure operating on a current of water closely confined, as in a tunnel, is the only reasonable theory that can be advanced in explanation of this phenomenon.

The parallel esker ridges which together constitute the larger belts, may probably be explained by supposing that, where the stream course was determined by a broad valley, the exact situation of the tunnel varied from time to time, perhaps because of more or less transverse ice-movement. Under this hypothesis, the individual ridges of a given section of the belt were not strictly contemporaneous, although nearly so. Evidence strongly supporting this proposition may be derived by an examination of the internal structure of the deposits. Where several ridges adjoin, the deposits of one will be found to overlap on those of a neighboring ridge, and to be in turn overlain by those of another.

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*The deposits referred to consist of a loess, averaging a few feet in thickness, but increasing in places to eight or ten feet. This is confined to such basins as would be formed by the closure on the east of certain valleys at the time when the ice-front stood about twelve miles back or east from the outer glacial border. The surface of the loess has been formed, during the Aftonian epoch, into a black soil varying from one to three feet in thickness. There are also indications of some erosion of the loess at this epoch. During the ensuing Iowan epoch, the black soil was covered by eight to ten feet of Upland loess, giving the now buried black soil an interloessial position. I shall refer to the lower loess in Stephenson county as the product of Lake Lena.

In summarizing the evidence which is furnished by the phenomena connected with the stratified sand and gravel beds of this district, we find that it clearly proves (1) that they owe their existence to subglacial streams which flowed at so low a level as to derive the material very largely by direct erosion; (2) that these streams flowed westwardly into extra-glacial lakes; and (3) that the main period of excessive melting occurred some time after the Kansan ice-sheet had begun to waste away or its front to "retreat." It less clearly shows (4) that the deposits as now seen are those which were laid down along the last few miles of the tunnels, and more particularly at or just beyond their mouths; and (5) that the "areas of special development" indicate the position of a *terminal line* during a halt in the recession of the ice-front. The terminal lines here referred to apparently correspond to the terminal moraines of a later glacial epoch. It is evident that, if we are able to discriminate the several "special areas" in the different belts, and to correlate them, we can read the history of the moraineless drift of northwestern Illinois almost as readily and completely as that of the districts abounding in large and distinct moraines. However, to endeavor to locate these terminal lines by means of the stratified drift alone is rather a questionable proceeding; but if the lines so indicated are supported by evidence of other classes, their positions may be considered as demonstrated. Under the next heading I shall endeavor to indicate the nature of this corroborative evidence as displayed in this district.

Eskers are considered to have been formed by streams which flowed through or under the ice-sheet, generally parallel to its direction of movement. To this class I would refer nine-tenths of the stratified drift ridges of this district. Kames are considered to have been formed by streams which flowed down over the face of the glacier, or which welled up between the ice and its terminal moraine. They indicate the position of the glacial front during a period of halt or slight readvance. Where moraines are well developed, kames are of inferior importance; but in the absence of distinct moraines, their existence is of primary importance in determining the sub-stages of the general recession. To this class probably belong many of the small, apparently isolated, gravel knolls of the Pecatonica basin. Perhaps the "areas of special development" should be included in this class, as they are essentially "terminal" deposits. Topographically and structurally, they combine features elsewhere peculiar to both eskers and kames; but they may perhaps be properly considered as a sub-class by themselves. Some of their characteristic features are due to their having been formed at the mouths of esker streams, where the ice-sheet was bordered by extra-glacial lakes.

TRANSPORTED ROCK MASSES.

One mile north of the city of Freeport, on the low bluff which bounds the Pecatonica river valley, there is a small knoll of stratified waterworn gravel and sand, constituting a portion of one of our secondary esker belts. It is capped by a six foot stratum of angular limestone gravel. As this deposit is typical of the class, we will examine the angular gravel closely. It consists exclusively of Galena limestone, the terrane which is exposed throughout the region. No drift pebbles of foreign derivation are found in this stratum. All the material is sharply angular, and in no portion of the deposit does it show any evidence of water action. The material varies in size from fine sand to small boulders, and these are agglomerated in the irregular manner common to till. The same deposit appears in a neighboring quarry as a six foot stratum of broken rock, resting on the somewhat smoothed upper surface of the solid limestone. A portion of the angular gravel bed still retains evidence of the original stratification of the undisturbed rock.

Half a mile east of Taylor's Park, in East Freeport, a quarry has been opened into the west end of a short ridge. This quarry or pit exposes a thickness of eight feet of angular Galena limestone gravel, and the base of the deposit is not seen. The original bedding planes of the rock have been generally destroyed, except at one end of the excavation, where they excavations, the incoherent portions are found to alternate, both horizontally and vertically, with other portions in which the original bedding planes have been but little disturbed. This is characteristic of this class of phenomena, and constitutes a link between the tilted but not transported rock and the perfectly commingled angular deposits. One of the former varieties is well displayed in a road cutting in this region, where the upper twenty feet of the limestone *in situ* has been folded by the pressure of the ice applied from the northeast. This fold shows dips of 30°, and the strata near the surface are somewhat broken. Of the many deposits in which the material has unquestionably been transported from the parent ledges, I will describe a few of the most significant.

6. In the center of a small valley two miles west of Dakota, there stands a single cone-shaped mound about 30 feet high. It is composed of Galena limestone, not much broken, but with the strata dipping steeply in every direction from the center and top of the mound. Burrowing animals bring out waterworn drift gravel and sand from under the limestone at the base of the mound.

7. Three miles west of the village of Dakota, there is a short ridge of broken limestone, standing in and nearly obstructing a deep valley. This ridge trends east and west, and is perhaps 75 feet high. Angular pieces of Galena limestone are exposed all over the surface, except at the base, where burrowing animals, as in the former case, bring out waterworn gravel and sand.

8. Three miles southwest of Dakota, the Chicago, Milwaukee & St. Paul railway passes a high rock ridge, making a long deep cut into the Galena limestone. On the western side of this ridge, both north and south of the railway, there are huge piles of broken limestone, which, at first sight, might be confounded with the similarly shaped masses which were taken out of the rock cutting and piled up. However, the amount of the material, the distance from the railroad, and the fact that a line of these knolls extends thence northwestward for a long distance, must soon convince the observer that these deposits of angular gravel are a natural formation.

In discussing the significance of these accumulations of angular local limestone debris, I wish to call attention to certain features which are common to all of them.

a. There is never the slightest evidence of water action, either in eroding the material from its parent ledges or in depositing it.

b. The eastern end of a given ridge or mound is usually a gentle slope, while the western end is almost invariably abrupt.

c. The sharp contours, especially of the isolated cone-shaped mounds, negative the idea that they were ever overridden by the ice, and show that they are not preglacial in age.

d. Except in a very few instances, practically no drift pebbles whatever have been found within the body of these deposits, whereby they are denied admittance into the ground moraine as unusually stony portions of the till.

e. There are generally a few boulders of the englacial drift scattered over them, demonstrating that they are not postglacial or even post-Kansan in age (except the sharp ridge southwest of Pecatonica).

f. The almost total absence of foreign drift within them clearly proves that they were not lifted up and carried in the ice-sheet as englacial drift.

g. The occurrence of the deposits as high ridges and cone-shaped mounds, in the center of valleys and overlying stratified drift, shows that they are not now *in situ*, but have been transported from some distant ledge.

h. Their situation, in the majority of cases, west of the crest of a high rock ridge, indicates their derivation from it, and we are thus enabled to determine that they have sometimes been forced up a slope to a considerable hight above the parent ledges.

I think that the glacial origin of these peculiar gravel deposits will not be disputed. It has been suggested that similar agglomerates of broken rock might be produced by a land slide, or even by the slow "creeping" of the strata down a slope. This, however, requires that the parent ledges shall be situated at a hight considerably above the finished deposit. As we have seen, there are deposits in the Pecatonica basin which rest on the summit of esker knolls higher than any rock ridges in the vicinity.

The glacial age of the angular gravel beds having been demonstrated, it remains to determine the precise mode by which they were formed. Obviously, the transporting power was supplied by the forward movement of the ice-sheet. The advancing ice, in ascending a rock ridge, abraded the loose upper strata of Galena limestone, and forced them forward in front of it, continuing to do so as long as the front advanced. As soon as a retrograde motion of the ice-margin set in, the deposits of angular limestone gravel remained in ridged accumulations along the terminal line of the just ended stage of advance. Since they have not subsequently been overridden by the ice, we may thus accurately determine the position occupied by the ice-margin at the culmination of each re-advance. Where the deposits are heavily developed and a persistent line of knolls is found to correspond with the reputed trend of the ice margin in that portion of the district, we may safely conclude that this line represents the culminating limit of some stage of glacial re-advance. Furthermore, upon projecting our supposed terminal line across one of the more prominent esker belts, and finding it to intersect an "area of special development," we may conclude that the line thus established is not merely hypothetical.

The combined phenomena of the angular gravel knolls and the "special areas" of the esker series constitute the Kansan representatives, in the Pecatonica basin, of the terminal moraines of the Wisconsin epoch. Along these morainic or terminal lines there is often a slight thickening of the ground moraine, with an increase in the amount of englacial drift. It is evident that a more plentiful supply of material and the proper length of time would have sufficed to form massive moraines. But in the eastern portion of Stephenson county, where the angular gravel deposits are most numerous, the amount of foreign drift is small. In fact, the general absence of any typical moraine material in the vicinity of the broken limestone deposits is one of the most remarkable characteristics of their occurrence. It indicates, I believe, that the knolls were formed with great rapidity. Between the main lines of knolls, which apparently represent terminal lines of a moraine-forming period, there are smaller deposits, each of which may possibly be the result of a single season's work. If this could be proved, it would furnish data for computing the rate of general recession of the ice-front across the district; but a very large amount of work will be required yet before any dependence can be placed on a computation based on this principle.

TERMINAL LINES IN THE PECATONICA BASIN.

On the map facing page 198, I have endeavored to roughly indicate the positions of some of these supposed terminal lines. In mapping margin No. 1, which is the outer drift margin, I have followed Chamberlin and Salisbury, Leverett, and Buell, with a few modifications due to personal observation. Margin No. 2 may seem questionable, but from the facts that the "special areas" which indicate it are the most western in their respective belts, and, when favored by the presence of valleys, are well developed, I am certain that they indicate a terminal line, although not a very important one. The problem lies in their correlation. Margin No. 3 is more definite, however, for it is marked by an unusually developed "special area" in the Pecatonica esker belt, and by an important one in the Cedarville belt. These are practically the western termini proper of their respective belts, and indicate the institution of vigorous melting and large subglacial streams. While the ice-sheet was wasting away from the country west of this line, the climate was still moderately severe and melting was at a minimum. But from the time when the ice-front passed the line indicated by margin No. 3, it was subject to rapid destruction. Between the two esker belts, margin No. 3 is further defined by a thickening of the till, which is sometimes massed into a low, smooth, moraine-like ridge. A boulder belt also appears at intervals along this line. It apparently bounds the loess deposit of Lake Lena, with its accompanying black soil, on their eastern side; and the main deposition of the silt is considered to have been contemporaneous with the sub-stage of the ice-sheet during which its front coincided with margin No. 3. If we may judge from present evidence, the ice-front remained longer on this line than at the outer drift margin. It was, also, a more important sub-stage* than any which followed.

Margin No. 4 is indicated by a "special area" in the Cedarville belt, which apparently corresponds to one in the Pec-

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*The term *sub-stage* is used in this paper as a synonym of the moraine-forming subdivisions of the grand stages or epochs of glaciation, such as that which formed the Wisconsin drift-sheet.

atonica belt. I think that a north and south belt of gravel knolls, two miles west of Freeport, belongs to this terminal line, having more of the nature of kames than of a true esker belt. Following this line south of Yellow creek, it appears to pass into a broad smooth ridge of till, which crosses and completely obstructs the preglacial valley of that stream. This same line is represented by discontinuous ridges extending across the divide into the Leaf river basin, where it is located by a "special area" in the Adeline belt.

The mapping of margin No. 5 is based solely on "special areas;" but in margin No. 6 we again find a pretty well defined line. The situation of this sixth terminal line is marked chiefly by a number of prominent angular gravel knolls, but it also intersects an important "special area" in the Pecatonica valley. This line was probably second in importance to No. 3 only.

In addition to the six marginal lines of the Kansan drift sheet that I have here indicated, there are evidences of many more; but because of their indefiniteness I have preferred not to map them at present. It should be stated, however, that, while the more western margins have a tendency to project outward on a line trending northwesterly from the city of Freeport, there is a straightening of the later terminal lines lying nearer the Pecatonica lobe of the Iowan drift sheet, so that there is a discordance between the systems of the two glacial epochs.

CONCLUSION.

Reviewing this discussion of the eskers and intimately associated deposits of the Pecatonica and Leaf river basins, I wish to call special attention to the following facts:

1. Not only the trends of the individual ridges, but also of the completed esker belts, are always at right angles to the first terminal line west of a given point, and apparently parallel with the general direction of movement in contiguous portions of the ice-sheet, as indicated by phenomena independent of the eskers. By diligently observing the stratified drift, we may determine the direction in which the ice-sheet moved in every portion of the district. We thus learn that the general direction was west-southwest until it reached a line extending north and south across the Pecatonica basin, a

few miles west of Freeport, where it rather abruptly changed to the northwest and continued so to the outer drift margin.

2. The *mer de glace*, in retreating, withdrew more rapidly in the southern portion of the district than in the northern. The belt between the outer margin and No. 3, in which the deposits of stratified drift are very poorly developed, and which is twelve miles wide on a line due west of Freeport, may widen out toward the south so as to constitute perhaps the entire width of the exposed area of Kansan drift south of Rock river. The next great belt of Kansan drift, which contains heavy deposits of stratified drift of the esker series, and which is twenty miles wide in the Pecatonica basin, probably broadens out toward the southeast; but, passing under later drift sheets, it is perhaps not exposed south of the Rock river.

3. The esker belts, with their "areas of special development," and the angular gravel deposits, being demonstrably contemporaneous phenomena, postulate a very vigorous movement in the glacier at the same time that its borders were being rapidly melted.

In short, from a study of the phenomena displayed by the older drift in the Pecatonica basin, we learn that the ice-sheet of the Kansan epoch, at least in one district, and probably in all, was not of such insignificance and inefficiency as many glacialists have supposed.

HORNBLENDE-BASALT IN NORTHERN CALIFORNIA.

By J. S. Diller, Washington, D. C.

While making a geological survey of the Pitt river region, at its great bend, in Shasta county, California, I found in Kosk creek, about a mile above its mouth, a large, well-worn cobble-stone of an eruptive, quite unlike any other yet observed in that district. The locality is just beyond the northwest corner of the Lassen Peak sheet of the U. S. Geological Survey. Although not found *in situ*, this brief notice of the rock may be warranted on account of the rarity of its type in this country. The fragment was evidently brought down by the stream from the rugged canyon above, where a large series of Paleozoic, Mesozoic and Cenozoic sedimentary rocks are associated with various eruptions.

Upon examination, the rock proved to belong to the type generally known as hornblende-basalt. It is a dark, heavy rock full of prominent crystals of hornblende from 4 to 25^{mm} in length. They are equally distributed, and appear to form 10% of the whole mass. A few small rusty and white spots are due to olivine and feldspar. The phenocrysts are in a dense dark groundmass, which, to the naked eye, looks like ordinary basalt.

In the thin section, the deep brown basaltic hornblendes are seen to be rounded and embayed. They are anhedral instead of idiomorphic, as phenocrysts usually are, and each is enclosed in a dark, magnetitic border, characteristic of hornblende that has been corroded and partly resorbed by the magma.

Although most of the hornblende is fresh, some of it has entirely disappeared, its place being occupied by a dark group of granular augite and magnetite. Some of the crystals show twinning parallel to the orthopinacoid. Although the twinning plane of inclined sections occasionally makes a considerable angle with the prismatic cleavage, as shown by Becke, this is not exceptional. Pleochroism is strong, varying from dark brown to light yellow. There are a few sharp crystals of augite with lateral pinacoids well developed and some are twinned parallel to one of these planes. Neither the augite, olivine, nor feldspar show definite resorption phenomena. The olivine rarely has traces of crystallographic outlines. Much of it is changed to serpentine.

The groundmass is almost holocrystalline, composed chiefly of plagioclase and augite, with much olivine and magnetite, a few good crystals of apatite and a trace of clear base. The larger feldspar crystals are squarish and generally show numerous twinning bands. The more abundant smaller crystals of plagioclase are lath-shaped. Much of the yellowish green augite is in similar crystals with a large angle of extinction. Rarely it appears in irregular granules clamped between the feldspars, suggesting ophitic structure. The magnetite is often in sharp crystals. Some of it is probably titaniferous, judging from the analysis.

The following chemical analysis of the Kosk creek hornblende-basalt (No. 2) was made by L. G. Eakins in the chemical laboratory of the U. S. Geological Survey. For comparison the following analyses are added: (No. 1) Hornblende-basalt from Todtenköpfchen, described by H. Sommerlad in Neues Jahrbuch, Beilage Bd. II, 1882, page 155. (No. 3) Kulaite, a variety of hornblende-basalt from Kula Basin, in Lydia, described by H. S. Washington, in the American Journal of Science, February, 1894, page 122, and in "The volcanoes of the Kula basin in Lydia," page 57. (No. 4) Camptonite, from Campton Falls, New Hampshire, analyzed by L. G. Eakins, in the chemical laboratory of the U. S. Geological Survey.

	1	*2*	*3*	*4*
SiO_2	42.68	44.77	47.50	38.45
TiO_2	.....	.53	.....	.....
Al_2O_3	9.42	17.82	19.32	19.68
Fe_2O_3	11.55	5.05	4.75	4.01
FeO	7.23	6.95	5.20	11.15
MnO	.....	trace	.....	trace
CaO	13.15	10.36	8.37	9.37
MgO	10.09	8.22	4.36	6.65
K_2O	1.16	.92	2.31	1.72
Na_2O	2.71	2.13	7.63	2.77
H_2O	1.06	2.64	0.46	1.49
	99.05	P_2O_5 .72	0.21	4.82 $=Co_2$
P_2O_5	1.29			
TiO_2	.51	100.11	100.11	100.11

In chemical composition the California rock lies between that of Todtenköpfchen (No. 1) and of the Kula basin (No. 3).

The rock described by Sommerlad gelatinizes by hydrochloric acid, and is reported to contain nephelite. Kulaite contains much more Na_2O, but no reaction for nephelite was obtained. However, a trace of leucite was found. The Kosk creek rock does not gelatinize. The large amount of water it contains is due to the serpentine.

J. Hazard has recently described* from the Lausitz, in eastern Germany, an interesting series of hornblende-basalts occurring in volcanic necks (Ausfüllungsmasse der Eruptionscanäle). The surface flows (Decken) and the dikes (Gänge) of the same region, are free from hornblende. Although many basalts occur in that region, all forms of them appear to contain nephelite.

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*Tschermak's Min. und Petrog. Mitt., vol. XIV, 1894, p. 297.

THE GEOLOGY OF A TYPICAL MINING CAMP IN NEW MEXICO.

By C. L. Herrick, Socorro, N. Mex.

Plates XIII and XIV.

The Magdalena mountain range forms a comparatively isolated district and illustrates many of the conditions of mineral accumulation, as well as a variety of geological problems exceptionally well. Situated about twenty miles west of the Rio Grande valley, it forms a secondary axis parallel to the major one which must at one time have occupied the site of the present valley. The Magdalenas are situated upon the margin of the belt of Carboniferous limestone and sandstone strata so well seen at various points in the valley. As in the case of the other north and south ranges, the present mountain axis is near the base of the original anticline and exhibits the uptilted strata, here dipping with an inclination of about 45° to the southwest. The principal intrusives are found near the synclinal axis and contribute to the ore concentration.

The range, so far as studied, is about thirty miles long and, like all other axes of uplift in this region, is interrupted at intervals by local craters. In the present case the northern portion is relatively less disturbed, while the southern three-fourths is chiefly volcanic. The mineral association in the two portions obeys different laws and affords instructive evidence of the constancy of these principles under similar conditions. It may be premised that in this portion of New Mexico the sequence of eruptives has been from basic to acid. The older flows being usually andesitic, the following trachytic, while the latest are rhyolites. True, there are basaltic flows of a still later age, producing *mal pais* and recent craters, but this does not alter the general fact that the flows chiefly concerned in outlining the present geotechnic of the region obeyed this rule. Again, it is necessary to note that the stratified series is chiefly sandstone below and limestone above, so that in each case of uplift the lime has suffered displacement, while the subjacent sandstone has frequently been greatly metamorphosed even to the extent of transformation into gneiss or granite. In a general way it may be said that the northern portion of the range, being less fundamentally

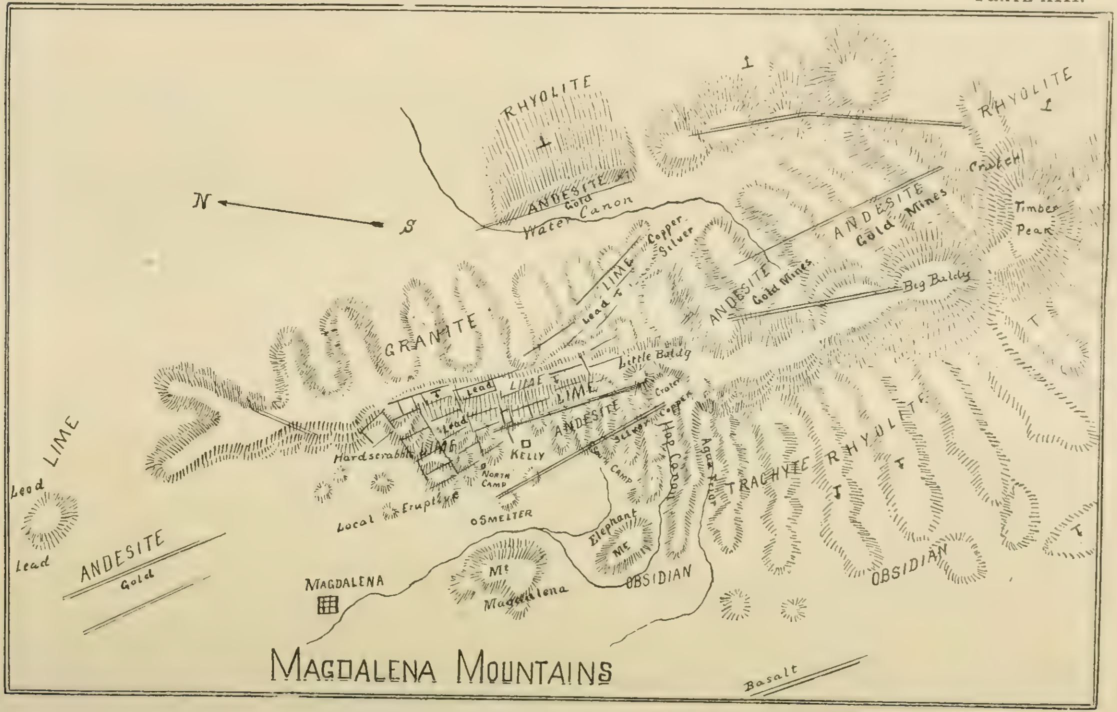

FIG. 3.—MAGDALENA MOUNTAINS.

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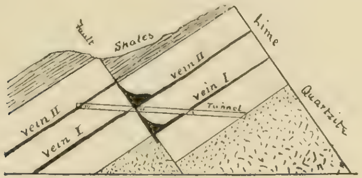

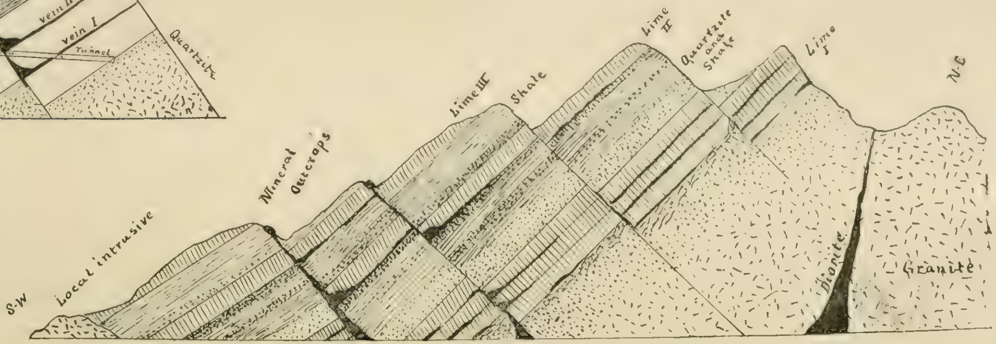

FIG. 1.—GENERALIZED SECTION SHOWING THE RELATION OF STRIKE FAULTS TO THE ORE HORIZONS.
FIG. 2.—ILLUSTRATING THE EFFECT OF FAULTS IN APPARENTLY INCREASING THE NUMBER OF ORE HORIZONS.

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altered, forms a lead mining region, including the famous Kelly camp with the Kelly and Graphic mines, which have produced a number of independent fortunes, as well as a large number of properties of less importance. The southern part of the range, on the other hand, is essentially a gold district, which, although still awaiting development, promises to be of substantial importance, as in Water Cañon, Six Mile Cañon and others.

The conditions at the north end of the range are apparently simple (plate XIII). An extensive uplift between the Socorro mountains and the present site of the Magdalenas has suffered erosion, leaving the western base as the present range. The three or four hundred feet of the upper series, consisting of limestone and sandstone in alternating layers has been tilted to an angle of 45°, exposing on the eastern slope several hundred feet of the altered acid series beneath. This series has here been transformed into a granite with only here and there a thin band of lime to indicate the original stratified condition.

Dykes of quartz intersect this series at intervals and are occasionally mineralized, but, as in the case of acid intrusives in acid country rock elsewhere, the concentration is apparently never sufficient to warrant exploration.

No very definite estimate can be made of the thickness of this lower series, for it has been too completely fused to retain any adequate data. It is frequently penetrated by bands of schist and dykes of diorite, but its upper layers retain a schistose or gneissoid character, and where they approach contact with the limestones become quartzites.

The contact of the quartzite with the lime is everywhere in evidence along the eastern face of the axis of the range in its northern portions and lies all the way from a few feet to two or three hundred from the summit, and is capped by one or more of the lower lime belts. The contact is apparently only irregularly conformable or the original conformity has been disturbed by more or less extensive interpenetration or solution along the lower contact. This contact is usually mineralized and forms the outcrop upon which many exploratory workings and a few producing mines have been placed.

The mineral association is usually iron, lead, silver and zinc with a predominance of sulphides. The quartzite is not rarely altered near the contact with the line to a chloritic silicious schist with epidote and calcite. This phase is called "greenstone" by miners. At various places dioritic intrusions penetrate the quartzites and cause local and perplexing disturbances in the rather uniform stratigraphy. We may presume that the lead in this region has been derived from more or less generally disseminated deposits throughout the limestone, and the probability is that it was originally in the form of galena. The present situation and composition of the lead is, however, to be ascribed chiefly to the influence of percolating waters with the coöperation of metamorphism. At this lowest lime contact both factors assisted. The limestone is between seventy-five and one hundred feet thick, and has been greatly altered in so far that it forms a coarse white marble in several localities. The effect of metamorphism is seen not only in the crystallization and decolorization of the lime, but also in the segregation of the silicious matters as bands of chert or flint. The lower portions especially are silicious and metamorphic. The fossils have usually suffered from metamorphism, though occasional crinoid stems occur. The location and association point to a middle Carboniferous age. The ore is usually near the contact, though it may be several feet distant. In at least two horizons within this limestone other ore concentration has occurred, but only in certain localities do they become important; yet where this is the case they are often very valuable, since the ore is collected in old water courses lying in plains of seepage, under conditions for solution of lime and redeposition of ore. The lower contact, as stated, contains chiefly sulphides, yet the lead is frequently reduced to sulphate or altered to a carbonate in such situations as have permitted a free percolation of waters from higher deposits. It is interesting to note that the mines opened along the summit of the range where cut off from such supplies are usually of small value, being poor in ore, which is here chiefly a sulphide. The silver value is, it is true, higher than farther down, but as this is subordinate practically to the lead, it does not repay for a lower lead contact and the absence of large cavities with carbonate of lead. This difference between the higher and lower portions of the same series is in conformity with what has already been said as to the probable method of concentration. Here at the summit there is less opportunity for percolation and none for deposition of solutions from other regions. The leaching, if it has occurred, has only impoverished the strata.

In general, it may be said that any one of a number of impervious strata (quartzite or silicious shale) associated with the several limestone belts may become barriers to the transverse motion of the mineral-bearing waters and, by consequence, give rise to a metalliferous horizon. The ore in such cases is usually concentrated along lines of least resistance, inclining at various angles within such horizons. These water courses produced "pipes" or "shoots" in the ore zone where great masses of lead carbonate, smithsonite and other minerals were deposited obviously from aqueous solution.

The lead, however, must have originally been galena, as cores of that mineral are very generally found within masses of lead carbonate. The larger cavities or chambers are frequently exceedingly beautiful, and a single such chamber has frequently yielded a good fortune. The walls are water-worn, encrusted or stalactitic. Oracalcite, smithsonite and blende occur with the prevailing cerussite.

Were the conditions as simple as hitherto implied the work of prospecting would be of the easiest, but, on the contrary, the whole area is intersected by faults in two or more parallel series. One series of strike faults give rise to minor ridges parallel to the main axis on its western slope, repeating the sequence to a greater or less extent in each case till the level of the valley at the foot of the isolated Mt. Magdalena about three miles west of the main range is reached. The western margin of this faulted area is formed by an independent basic uplift, which may be said to have prevented the sheet from reaching the degree of depression to be expected theoretically. This intrusive may be traced to the most northern crater of the series and is approximately parallel to the main axis. The strike faults above mentioned are quite numerous—from six to twelve major ones and many minor ones can be recognized. They are not strictly parallel to the range, but extend south 30° east at right angles to the dip. The dip of the western blocks is less, a fact accounted for, as above seen, by the uplift of the secondary intrusive.

The fault planes have an important bearing on the ore concentration in two distinct ways. The larger faults toward the west, i. e. nearer the theatre of true volcanic activity, have afforded means for introduction (by sublimation) of other minerals than those indigenous to the limestone strata. These breaks intersect the several ore horizons and may afford opportunity for concentration, and they also afford outcrops or surface indications which, in several cases have led to the discovery of the real "blankets" of ore below. The second way in which the faults contribute to ore accumulation is by interrupting the downward movement of waters carrying mineral in solution. Where the throw has been slight this has produced an accumulation in the space between the lower and upper intersections of the faulted ore zone with the fault plane, thus, fig. 1. These accumulations had been recognized by the more intelligent miners, though not explained by them. The fault plane, though mineralized, contains less lead and more iron (sulphides), and frequently more silver (a fact suggesting that the silver has had a different origin from the lead—perhaps sublimation).

The fault planes of this order have also greatly interfered with the working of many mines by causing obscurity as to the actual number of ore horizons. The apparent number is often the result of reduplication, as indicated in fig. 2. Still more annoying, and without any compensating advantages, are the dip faults, which are even more numerous and far less regular than the previously mentioned. A ride along the crest of the range from north of Kelly to the Little Baldy Mt., at the north end of the eruptive area proper, reveals a very large number of such faults with a throw of from a few feet to several hundreds. The reason for these is readily seen in the fact that the lateral thrust has not been uniform, but greater to the north, so that the edge of the stratified series is not parallel with the summit but somewhat diagonal to it, crossing from west to east some miles from the northern end of the range. What comes to the same thing is the fact that the granite uplift was greatest to the north, the metamorphosed material having been squeezed up and occupying the whole north end. The influence of these faults seems to have been nil, so far as the ore deposits are concerned.

Turning now to the more strictly igneous portions of the range, it will be remembered that the southern part of the series is broken by a number of craters. The most northern lies near Little Baldy or, more strictly, that peak is a part of the limb of a large crater at the head of Hop cañon. The earliest eruptions were of great extent and were basic. The crater just referred to is of andesitic tuff, and the great brecciated masses bear witness to explosive periods of great violence and extent. What is true of this crater is apparently also true of all the others. Opportunity is afforded for verifying this belief by a vast series of flows which have been left exposed by the cataclysm producing Water cañon. This profound break on the eastern slope leaves a vast, nearly perpendicular wall facing the west and parallel to the range. This wall is composed of a tremendous mass of andesitic breccia, inclining to the east, bearing evidence of a marvelous outburst which must have come from the west in the very region above described. Above this breccia is a series of flows of acid nature, the latest being red rhyolite.

Further south the same sequence is to be found, though much disturbed. The rhyolite was evidently very fluid and spread over a very large area, even outside the immediate sphere of the volcano. The greater part of the western aspect of the range is hidden by acid flows which were very widespread and must have been exceptionally quiet and prolonged. These flows were repeated at frequent intervals without intervening change of level and extended many miles to the east. Subsequent erosion has carved out cañons and left isolated, butte-like peaks, but everywhere the original continuity is visible. Some of these flows were obsidian of nearly a white color, others were trachytes and interesting trachyte pitchstones, while the latest were rhyolitic. A very curious occurrence in the vicinity of Texas spring is a breccia of black obsidian in a tuff-like magma. Chalcedony in amygdaloidal cavities and veins is very common in this acid series. The rhyolite and trachyte series is not mineral bearing, and the efforts of prospectors on the vast areas so covered have been uniformly futile, though the period of acid eruption is not to be considered as unimportant from an economic point of view. The most interesting opportunity for studying the acid series is afforded by the isolated peaks west of the Magdalena range proper, as in Magdalena and Elephant mountains which are parts of the great flows above indicated.

The large mountains forming the nucleus of the range, preeminently Big Baldy and Timber peaks, are also volcanic, and although capped with acid rock, occupy the place of an old andesite eruption. The latter occupies the east side of the main range southwest of the cliffs of Water cañon, and forms the country rock in which the gold segregation has occurred.

It is perhaps of more geological than economic interest to determine the age of the dykes of acid matter which, by intersecting the andesite, have provided the conditions for ore concentration in this district. The results of a brief study of the field seem to suggest that the acid intrusives are of the same age as the later flows above described. The gold seems, however, to be derived from the andesite so that the ore is chiefly in selvages or brecciated margins rather than uniformly distributed in the quartz. A thorough petrographic study of the region has been begun but would not be admissible here.

Enough has been said to indicate that a careful geological survey of the region would have important bearings on the economic development of the mineral resources.

Througout the entire region so far as studied, there is no important exception to the rule that gold is segregated along contacts of acid rocks with basic intrusives or the converse. Andesite is preëminently the gold-bearing country rock.

VALLEY GLACIERS OF THE UPPER NUGSUAK PENINSULA, GREENLAND.

By Ralph S. Tarr, Ithaca, N. Y.

Valley Glaciers of Greenland. Passing along the Greenland coast, one is almost constantly in sight of valley glaciers. Some of these are tongues from the great ice cap, but many are furnished with their supply from local snow fields. These are particularly abundant in the Vaigat straits and in Umenak fjord Here one sees every gradation between the large, well defined glacier, terminating in the sea, and mere snow banks.

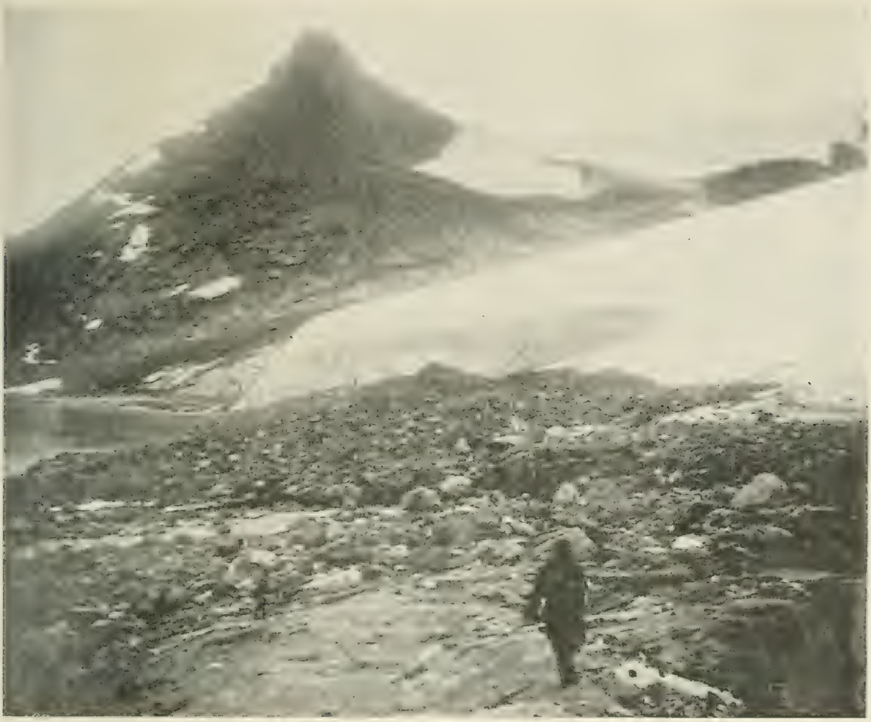

FIG. 1.—THE SEA TERMINUS OF NUGSUAK GLACIER.

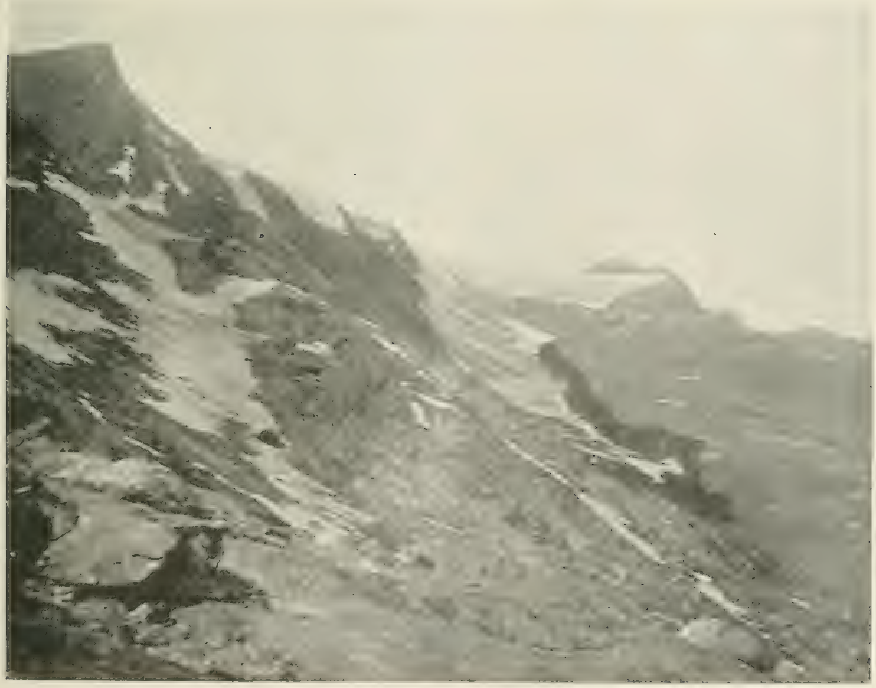

FIG. 2—A DYING GLACIER. UPPER NUGSUAK PENINSULA.

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The glaciers seen on the west side of Vaigat strait are furnished with their supply from the local ice cap, which overspreads the most of Disco island. In the neighborhood of Godhaven, the ice cap is easily reached by a climb of 2,500 feet, and at this point is found to possess an attenuated edge. In going from the land to the ice, one passes over patches of snow, then, almost imperceptibly, attains the ice cap edge without steep ascent. This is entirely different from the edge of the main ice cap which, everywhere that I saw it, presents a distinct slope, and oftentimes a precipice toward the land. Near the middle of August the surface of this attenuated edge was wet and slush-covered, with innumerable streams flowing over its surface. Even at a considerable distance from the margin, and at an elevation of 3,200 feet similar conditions exist.

Time did not permit extensive exploration of this ice cap, but viewed from a high place (about 3,200 feet above sea level) it was seen to extend many miles toward the interior of Disco island, with a very irregular surface, evidently conforming to variations in the under topography. Along the margin, where we approached the glacier, there was no evidence of motion, but every appearance of nearly perfect stagnation. Descending from this place, which was a divide, toward the valley on either side, evidence of motion was found in the crevasses which break the surface of the ice cap. Passing down one of these valleys, it is found that the ice projects as a valley tongue; and in the case of the larger valley, as a distinct glacier. On the margin of one of these valleys the ice cap comes to the edge, in some places forming a precipice, in other places hanging down over the edge of the cliff as a hanging glacier.

In several of the valleys visited by different parties, evidence of former greater ice extension was found in the presence of moraines, both marginal and terminal, beyond the present ice margin. Another notable feature of the glacial geology of this island, was the presence of gneissic boulders stranded upon the trap rock which forms the cap of this part of Disco. These boulders extend all the way up to the edge of the ice. Whether they were brought to their places by the glacier, at some time when Disco island was more extensively ice covered, and brought from within the island itself, or whether they were brought to their present places by a more general ice sheet, reaching out from the mainland, was not determined. No doubt a study of the bed rock on the mainland, and a comparison with the transported boulders will decide this point. From what I saw farther north, I am inclined to believe the latter the more probable explanation.

The Looped Glacier of the Upper Nugsuak Peninsula. In the Upper Nugsuak there is no *general* ice covering at present;* but there are numerous glaciers of various sizes, resembling in many respects those that were seen further south. The largest valley glaciers of this peninsula were located on the northern or sheltered side, and in the inland valleys, at the base of a high mountain which reached from 2,500 to 3,000 feet above the sea. In such an interior valley, near the middle of the peninsula, a glacier descends toward the interior from the extensive snow fields, which also supply another glacier, described later as the Nugsuak glacier. The tongue which descends toward the interior was call the Looped glacier, because of the outline of its margin. It is a hanging glacier, descending from the edge of a low part of the valley wall. In some portions the looped edge is attenuated, and ends in melting ice, with no sign of movement, and no distinct moraine. In the main and northern loop, the ice assumes the condition of a true valley glacier, whose surface is roughened by crevasses and by melting. Its terminus is a precipice, and its base is lined by morainal debris. In the lower layers of this tongue there are distinct dirt bands and many boulders. The glacier presents no specially remarkable features, and is merely mentioned to illustrate one of the conditions of glaciation at present existing on the Nugsuak peninsula.

The Nugsuak Glacier (Fig. 1). From the same snow field as that which furnished the ice for the Looped glacier, there descends, from an elevation of probably not less than 2,000 feet, a distinct tongue of ice, the most notable valley glacier on the peninsula. Its valley walls are steep on the eastern side, and only moderately steep on the western side. There are no distinct marginal moraines, although at places accumulations of debris extend to the edge and top of the ice. This glacier, which discharges the greater part of the surplus of snow in the snow fields of this place, is now just able to reach the sea. In one place the ice front is bathed by the waters of the fjord; but the greater part of the front, which is about 250 yards in extent, is terminated by a small marginal lake, or else by moraine upon the land.

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*This peninsula is in latitude 74 deg. 10-15 min., and was the place selected for study by the Cornell party which accompanied Lieut. Peary in the Greenland Expedition in 1896. Besides myself the members of the party were Prof. A. C. Gill, and Messrs. J. O. Martin, T. L. Watson, E. M. Kindle and J. A. Bonsteel. To all of these men I am indebted for valuable aid in my studies.

The lake, which is moraine dammed on the seaward side, stands at an elevation of about five feet above high tide. The moraine at the terminus is very bouldery, and in some places rests upon an ice foot, forming a thin film. However, in the part where the dam of the lake is built, the moraine is situated in a place entirely distinct from the glacier itself, as if marking the recent retreat of the ice. The front of this valley glacier is steep, rising 50 or 60 feet, with an average angle of about 50°-60°, and in its base there are layers of dirt and boulders, some of the latter weighing two or three tons.

Dying Glaciers (Fig. 2). Besides these two valley glaciers, and one that was not studied, but which exists to the east of these two, there are many tiny accumulations of ice, which in some cases are distinct glaciers, in others apparently nothing more than snow banks. Among these there are banks of snow, or rather of ice compacted from the winter snow, which are not in movement, but merely remain from year to year. The depth of these may in some cases be 20 or 30 feet. There are other banks however, in which one finds lines parallel to the outline of the bed, and in the base of which are layers of dirt. Among these there are many that are crevassed on the surface, showing distinct movement, but no snow fields exist to supply the glacier. From an examination of a large number of these, I have no hesitation in affirming, that upon the upper Nugsuak peninsula one can find every gradation from the snow bank that is motionless, to the distinct valley glacier tongues supplied from snow fields.

Former Greater Extension. These small glaciers are called *dying glaciers*, and in this category may also be included the larger Looped and Nugsuak glaciers described above, although their death is not so near at hand. That these are not newly born glaciers, now expanding and increasing their range, is proved by the observations that were made in their neighborhood. Below some of these tiny snow-bank glaciers there were abundant transported boulders, resting upon bed rock which was striated. They had evidently been brought to their place by the glacier at some time when it was more extensive than at present. In all cases the striæ pointed toward the present glacier remnants, and showed the intimate connection between the direction of the ice movement and local topography. For instance, in the valley where the Looped glacier now ends, the striæ, which are very fresh, point towards the sides of the valley. Near the middle of the valley, and in the center, they extend down grade toward the sea on the northern side of the peninsula.

The same evidence of former extension of local ice sheets was seen near the margin of the Nugsuak glacier, where the rock near the front is striated by fresh grooves, and the rock surface is not covered by lichens, even in the smallest degree. There is every evidence that the ice here, on the northern side, and in the central parts of the Nugsuak peninsula, has very recently reached further than at present, and that the valleys have been filled by glaciers furnished from several snow fields. Several valley tongues have joined to form a single glacier, which has moved toward the north.

This evidence is in perfect harmony with that found along the margin of the continental ice sheet near by, as is described in another article. This sheet of ice is now retreating, and moraines recently abandoned are seen along its margin. Before this the ice of the continental glacier reached out beyond the outermost limits of the peninsula, involving the whole land in general glaciation, with the direction of movement from the east. This was succeeded by local glaciation, similar to that at present noticed in the ice cap of Disco, though less universal, partly because of the smaller land area, and partly because of the more irregular topography. During this time the ice movements were in various directions, and the transportation of fragments and the striation of rocks was in accord with the minor details of topography. The ice then moved in northerly, easterly, southerly and westerly directions, though the longest and most universal movement was the first, toward the west. Probably before the general ice covering, there was a stage of local valley glaciers, of newly born glaciers similar to those now dying. This more continuous glaciation, in the interior and shaded northern parts of the peninsula, has impressed itself upon the topography of the inland valleys in the form of much rounded roches moutonnées hills and rounded rock areas of smaller size. There is also a marked contrast between the fresh rock surface and the rounded appearance of the bottoms of these valleys and the more angular hill sides and hill tops which have been longer exposed.

Now most of these glaciers have disappeared, the largest being the Looped and Nugsuak glaciers, furnished from the same snow field. Even these are diminishing in size and many of the tongues which joined with them to form larger glaciers, are now present either in the form of nearly motionless glaciers, without snow fields, or else in the form of ice patches and snow banks, in the shady, protected valleys and mountain passes.

LAKES WITH MORE THAN ONE OUTLET.

By Thomas L. Watson, Ithaca, N. Y.*

The possibility of a lake basin having more than one outlet or overflow channel through which it drains has caused more or less discussion since the early sixties. The controversy first had its origin, so far as known to the writer, about some Norwegian lakes, but one which was especially significant at the time and caused considerable comment, was Lake Victoria-Nyanza. It was then given as the head-waters of the River Nile† and described as having three outlets. These, with other lakes, were described in the Athenæum‡ of London, and the controversy lasted from 1863 through 1866. This was followed by a second discussion in Nature* during the years 1873 and 1874, and numerous lakes with more than one outlet were cited from many parts of the world. Norway, the British Isles, Africa, Central America, the United States and Canada, were the countries from which this lake principle was illustrated. Since the first example was made known others have been discovered and published upon, from time to time, principally, of course, by exploration parties.

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*This essay is intended to represent a brief summary of the work done on lakes with more than one outlet, and citation of references to the literature, with a short description of several lakes of this kind noted by the writer during the past summer.

†Athenæum, 1863, vol. I, pp. 843-845.
Ibid., 1864, vol. I, p. 164.
Ibid., 1865, vol. II, p. 121.
Ibid., 1866, vol. I, pp. 367, 499, 564-565.

‡Athenæum (London)-1863, vol. II, pp. 19, 51, 113-114, 251-252, 578, 616, 652, 687-688, 718-719, 829-832, 838.

Many of the instances cited in the early and middle literature were by tourists, or for the most part, by untrained naturalists. If lakes were seen with more than one overflow they did not impress themselves upon the observer as being out of the ordinary—and in several cases were described from pure memory, after a long time had elapsed since the visit, which proved each time to be erroneous.

Several lakes illustrative of this condition, proved at the time to have two overflows, but after careful examination one of the overflows was shown to be artificial, serving the purpose of supplying water power for running machinery, etc. Colonel George Greenwood visited many of the localities from which this condition had been described, and succeeded in satisfactorily setting aside the statement, that these lakes were draining through two natural outlets. These with other careful after-examinations of the lakes first described has greatly diminished the number; however, there still remain a few which have not been disproven but stand as authentic, and every one, so far, is located in an area that has been more or less recently glaciated.

During the past summer while a member of the Cornell Greenland party in company with the sixth Peary Arctic expedition, the writer observed and noted several lakes having more than one outlet. These were scattered over the surface of an island located in Hudson strait, directly off the southern coast of Baffin land, named Big island. Two lakes of this kind were given special attention.

The first lake was a true rock basin, as one could walk entirely around it on the rock in place, save a short distance

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*Nature, 1873, vol. VIII, pp. 304-305, 382-383.
Ibid., 1874, vol. IX, pp. 363, 441, 485, 500-501.
Ibid., 1874, vol. X, pp. 5-6, 44, 124, 185, 408.

of some 50 feet. It was located in one of the fjord valleys, a short distance from the sea, and was rather small; averaging, about 100 by 40 rods in length and width. Apparently it had a fair depth for so small a body of water and was roughly triangular in outline. The two overflows were of about the same dimensions, one of them was a rock enclosed channel, the other was over a deposit of very large boulders, and both entered the sea as separate and distinct streams.

A very much larger lake was found some six or eight miles eastward from Ashe inlet, formed in the intersection of two broad and deep valleys, approximately at right angles to each other. This basin was more regular in outline and was discharging its waters through *five* separate and distinct outlets, which were well marked and defined and were about equally distant from each other.* They flowed from the same side of the lake and had the same direction seaward. It is possible, and perhaps probable, that they united into one large stream before reaching the sea. Time was insufficient to confirm this. The valley through which the outlet channels drained was filled to some extent with drift. It is a possibility and only so, since no evidence could be found favoring it, that during the breaking up of the long winter snows, which must be very heavy, the lake reached farther down the valley seaward, and what was seen as five distinct outlets, may be united into one common but temporary drainage channel to this basin. As I have stated this must be considered as only the barest possibility.

Bell†, Low‡, and Tyrrell§, have described a number of lakes in northern Canada with more than one overflow channel. Several of these are very large bodies of water, especially one described by Bell as having four separate and well defined outlets and draining north, south, east and west, and is some thirty miles in length.

Whether the condition is a permanent one lasting throughout the entire life history of the lake is at present quite beyond demonstration, and practically would be very difficult to prove, if ever. However this may be, it is an assured fact that lakes are known at present where the drainage is through more than one channel, and each one has been absolutely formed by natural processs, since they lie within the domain of an uninhabited region.

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*The writer crossed each one of the channels in sectioning the valley through which they coursed.

†Bull. Geol. Soc. Am., 1890, vol. I, p. 101.

‡The Geog. Journ. (London), 1895, vol. v, pp. 519, 532.

§Ibid., 1894, vol. IV, p. 438.

The opponents to the dual drainage lake existence have combatted more upon theoretical than practical grounds, since they insist that it is contrary to all known physiographic principles for a lake to exist with more than one natural outlet, for any length of time. For, given the two outlets, conditions will favor the one more than the other for lowering its channel, and just as soon as the one has reached a certain stage in erosion, this will form the permanent overflow, and the other will be abandoned. Theoretically this is true, but there are other considerations and some instances most assuredly prove that conditions are favorable and have been so, for the drainage of a lake through more than one channel at the same time.

EDITORIAL COMMENT.

SYNOPSIS OF THE DRIFT DEPOSITS OF IOWA.*

Studies pursued with the object of determining the distribution of certain types of soil and their relations to the drift sheets covering the state have incidentally demonstrated that the succession of Pleistocene deposits is more complete and more clearly indicated in Iowa than in any other corresponding area of this continent so far studied. The margin of the Wisconsin drift sheet was traced some years ago by Upham, but until recently this was the only Pleistocene deposit whose boundaries were approximately known. Two sheets of till were differentiated by McGee in northeastern Iowa, but it remained for the present survey during the past two years to recognize the southern limits of McGee's upper till. Mr. Bain has pointed out a body of drift below McGee's lower till, and sharply differentiated from it, and Mr. Leverett of the U. S. Geological Survey, has demonstrated the existence of drift in southeastern Iowa, intermediate in age, between the lower and upper till of McGee. The Pleistocene history of Iowa as now for the first time clearly deciphered, includes the following succession of events, each of which has had its influence in determining the present condition and characteristics of Iowa soils.

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*From the Administrative report of the State Geologist of Iowa for 1896.

I. First stage of glaciation, *Albertan*. Invasion of Iowa by glaciers and distribution of lowest sheet of till.

II. First interglacial stage, *Aftonian*. Melting and retreat of glaciers and deposition of gravels, followed by a long period of forest growth, development of soils, and modification of the original drift.

III. Second glacial stage, *Kansan*. Cold more intense and glaciation more general than during the first stage. Distribution of McGee's lower till.

IV. Second interglacial stage, *Buchanan*. Introduced by deposition of gravels in Buchanan, Black Hawk, Floyd, Cerro Gordo and other counties. This stage was very long and the surface of the second drift sheet was profoundly modified by erosion, oxidation and leaching before it came to a close.

V. Third stage of glaciation, *Illinois*. During this stage only a small part of Iowa, embracing portions of Louise, Des Moines and Lee counties, was invaded by glaciers. The ice came from the northeast, bringing boulders from the eastern shores of lake Huron.

VI. Third interglacial stage (unnamed), during which the modification of the second drift sheet proceeded over the greater portion of Iowa. The small area occupied by the third deposit of drift also suffered more or less of modification.

VII. Fourth glacial stage, *Iowan*. During this stage the northern half of Iowa was overrun by glaciers The southern limit of this incursion may be traced a few miles north of a line drawn from Iowa City to Des Moines, and then deflected northwestwardly to Plymouth county. It was during this stage that the enormous granite boulders so conspicuous in Bremer, Black Hawk, Buchanan and other counties in northeastern Iowa were transported and deposited where they now lie.

VIII. Fourth interglacial stage *Toronto* (?). This fourth interglacial stage was short as compared with the second, and probably with the third. The amount of erosion, oxidation and leaching that during this interval took place in the surface of the fourth sheet of drift is altogether inconsiderable. The amount of change that has taken place since the beginning of the interval up to the present time is comparatively small.

IX. Fifth glacial stage, *Wisconsin.* The last invasion of Iowa by glacial ice occurred in times so recent, geologically speaking, that the youngest sheet of till exists practically in the condition in which the glacier left it. The area in Iowa affected by this last invasion is nearly triangular in shape, the base of the triangle coinciding with the north line of the state from Worth to Osceola counties, with the apex located at Des Moines. In the northern part of this area there are numerous stretches of ill-drained lands, the surface is only very gently undulating and the stream channels, where defined at all, have cut only a foot or two into the prairie sod.

X. The recent stage, since the retreat of the Wisconsin ice, brings Pleistocene history down to the present. The recent stage, while long as measured in years, has been too short to produce any appreciable effect in the surface of the Wisconsin drift.

S. C.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The University Geological Survey of Kansas, volume II, by ERASMUS HAWORTH and assistants. (Pp. 318, plates XLVIII, Lawrence, 1897). Although the University survey has been somewhat hampered by lack of funds for their work, yet through the perseverance and untiring efforts of its director, aided by competent assistants, a second volume has been issued which is even better than the first report. In the first volume the stratigraphy of the eastern portion of the state was given, and volume II deals with the stratigraphy of the western portion, including the Cretaceous and younger formations. The report opens with an introductory sketch of Kansas geology, followed by a description of the physiography of western Kansas. At the close of Cretaceous time, the westward drainage system of eastern Kansas was turned eastward, so that with the opening of the Tertiary, probably late Miocene division, the drainage was similar to the present while the climatic conditions appear to have been very different. The two formations are separated by a time interval shown in the extensively eroded Cretaceous surface. Over half the Tertiary material is in the form of silt, clay and sand. The arroyos or short streams have great width of channel, very abrupt banks, and are dry during the greater portion of the year. Associated with them are sink holes containing water only after heavy rains. These basins form chains and finally pass into the form of the arroyo. Haworth believes that the soft sands settle and form the sink holes, and the water collects and drains down to the underlying clay. When the under surface is saturated the surface slips and creeps downward until the separate basins draw together and form the arroyo. This interesting theory seems to accord well with the observed facts.

The individual streams are described and discussed, and the Arkansas river might perhaps be taken as a type of these streams. This river was at one time 50 feet or more lower than at the present time, deposition is now in progress, gradually building the flood plain higher. A prominent feature of this river is the great bend commencing in the eastern part of Ford county. In an earlier epoch the river doubtless passed directly eastward, emerging from the state near its present location. As the river cut down into the soft Dakota it followed this formation northward until base level was reached, and the river could no longer corrode the Dakota bluffs. It was prevented from turning northward farther west, for the north bank was formed of the resistant Benton limestone until eastern Ford county was reached.

Professor Prosser's name is closely connected with the progress of knowledge of Kansas geology through his excellent work on the Permian, and his paper in this volume on the Upper Permian and the Lower Cretaceous will be read with interest. A review of former work is given, showing that considerable difference of opinion has existed concerning the line of division between the Permian and Cretaceous in Kansas. The upper fossiliferous shales and limestones forming the Marion formation are overlain by the Wellington non-fossiliferous beds, which have a maximum thickness of 445 feet. Above this group is the Cimarron series, or Red beds, consisting of red sandstone and shales without fossils and a layer of gypsum fifty feet in thickness. As there is no break between this series and the preceding, these rocks are provisionally referred to the Permian. The Red beds are clearly separated from the Comanche by an eroded surface. The second part of professor Prosser's paper is devoted to the Lower Cretaceous. He refers all the Cretaceous deposits, as far as investigated south of the Arkansas river, to the Comanche, which has two divisions separated by lithological and paleontological characters. First, the Cheyenne sandstone, which is a coarse grained, friable sandstone, about 50 feet thick, with rugged outcrop and containing fossil plants. Second, the Kiowa shales with their greatest thickness, in Clark county, 140 feet. The rocks are black and gray shales with vertebrate and invertebrate fossils. The distribution of the rocks is given with sections showing the order and thickness of the subdivisions. North of the Arkansas river, Kiowa shales are found at a number of isolated localities, reaching farthest north in Saline county.

The third paper is a description of the Upper Cretaceous of Kansas by W. N. Logan with an introduction by professor Haworth. These deposits cover an area in northern central Kansas, of 25,000 square miles, or nearly one-third of the state. The lowest division is the Dakota, which lies in a narrow belt forming the eastern border of the Cretaceous and consists of sandstone, saliferous and gypsiferous shales. A considerable number of fossil plants occur in this division and it contains two water horizons. The largest portion of the Cretaceous area consists of the Benton limestones and shales, 380 feet thick. The Niobrara, 400 feet thick, occupies a narrow belt along the border of the Tertiary area, and consists of the lower division, Fort Hayes limestone, and the upper division, Smoky Hill chalk, which is rich in fossils. The Fort Pierre shales occur in northwestern Kansas with a maximum thickness of 200 feet. This paper is followed by a short discussion of the rocks and fauna of the Kansas Niobrara by professor Williston.

Haworth, in another chapter, discusses the physical properties of the Tertiary. This material consists of gravel, sand, clay, silt, black sand and volcanic ash. The gravel consists of fragments of the crystalline rocks and quartz, while the sand is largely composed of quartz. The black sand consists of grains of black iron oxide mainly magnetite. The evidence from the surface and from deep wells shows that any one kind of material is irregular in position, and that there is no definite relation between the different kinds of material. The origin of the Tertiary materials is regarded as due to the decay of the crystalline rocks in the mountain area to the west, and they are regarded as river deposits rather than lake deposits.

In McPherson county occur alternating layers of sand and clay with a stratum of volcanic ash. These deposits belong to the Equus beds, and are described by Haworth and Beede. The beds occur in a valley cut through the soft Permian shales and Dakota sandstone and they cover an area of 900 square miles. The authors do not find evidence to support the glacial theory of origin advanced by Sharp, and the evidence is against the other theories which have been given by other workers. No satisfactory explanation of origin, nor the agency of deposit of material, can yet be given. On account of the level surface, good soil and abundant water supply, this district is one of the best farming regions in the state. In the final chapter, professor Williston describes the conditions existing in the Pleistocene in Kansas, and gives a list of fossil vertebrates in that group of rocks.

The present volume is uniform in size with volume I, but the general character of the papers is better, and the distribution of the plates through the text is an improvement. The typographical work is excellent and reflects credit on the state printer. The report will be sent to those who wish it, on receipt of 22 cents for postage. G. P. G.

Preliminary Report on Artesian Waters of a Portion of the Dakotas. By Nelson Horatio Darton. (Extract from the Seventeenth Annual of the U. S. Geol. Survey, 1895-6, Part II, Economic Geology and Hydrography.) In this paper we have another notable example of the way the government survey is throwing its energies into economic geology. The author may be congratulated on the able way he has collected and illustrated the facts known concerning this novel and most interesting resource of our northwest.

After a brief treatment of the geology of the water-bearing strata, with numerous cross-sections, he gives a detailed account of the wells by counties. Here are furnished figured sections of 133 wells, which afford an easy means of learning the character of the formations penetrated.

In discussing the sources of the water, the limits of the basin and the cause of decline of pressure toward the south and east, he agrees with other geologists.

Concerning the amount of the waters, he comes to a more hopeful conclusion than some others of the government survey who expressed themselves a few years ago. He thinks the areas of exposed permeable beds in Montana, Wyoming and Dakota connected with the supply may aggregate nearly 14,000 square miles, and says: "The present outflow of the wells can be but a small proportion of the intake of the beds at their outcrop at the very lowest estimates. This is quite clearly shown by the exceedingly slight influence in pressure that the wells have upon one another in areas where there are many wells quite near together." "It has been claimed by some persons that the pressure and yields of many wells are decreasing, but of this I can find no definite evidence that would indicate diminution in the water supply." "I see no reason why the artesian waters should not be produced in sufficient volume to supply all local needs of the usual kind and irrigate in a moderate way all lands to which their head will carry them. I believe there are no grounds for fear that the water will give out or prove inadequate for every need."

The availibility of the waters for irrigation is stated strongly. "There are now nearly 100 farms on which artesian waters are used for irrigation on a greater or less scale, not counting many gardens and several trial areas. In most cases the results have been so satisfactory that much interest and enthusiasm has been aroused." "It can not be claimed that all the artesian waters of the region will prove acceptable for irrigation, but it does appear probable that waters unfit for this use will be found to be very unusual."

An interesting account of the methods and results of such irrigation in South Dakota is given, with several fine illustrations.

In closing, two practical suggestions are given, one on the use of artesian water for power and another on the conditions and management of artesian wells.

The report consists of about 90 pages of text with numerous diagrams and illustrations and 9 well devised maps.

Some of the points specially novel or notable are the following:

The mapping and description of ten small artesian basins deriving their waters from the sands under the glacial drift. The main basin which has been referred to in most cases is from the Dakota sandstone, and possibly some older formations.

Another is the mapping of the floor of the artesian basin, or of "bedrock" under the Dakota sandstone. This has never been attempted before, and data are too few and too uncertain to do it satisfactorily;

still an attempt is commendable. Having given some attention to the subject we venture the following criticisms. In general the "hard rock" which he has thought to be the Sioux quartzite is probably not that, where remote from exposures of that formation, as at Wolsey, Aberdeen and Plankinton. At the last locality, according to the testimony of the well-borer employed at both, it was the same as found at Scotland, which was a sandstone cemented with lime instead of silica. Numerous hard layers occur in the Dakota sandstone, and it is not unlikely that some older rocks intervene between that formation and the crystalline rocks in the lower portions of the basin. Moreover, the samples of supposed "Archean rock" preserved in the high school collection at Aberdeen are a fine gravel, not crystalline at all.

Some rather striking irregularities represented in this floor are possibly traceable to misconceptions of topography. In fact one deficiency in the reports of the wells is the omission of the altitude of the mouth. This criticism probably applies to the bay-like depressions in northern Minnehaha and Yankton counties. That in Douglas county seems to rest on the somewhat doubtful evidence of one well.

To explain the irregularities of pressure, besides that of leakage along the eastern margin, our author recognizes local leakage, as at Chamberlin; the closing of certain water strata toward the east while others are open; and the varying coarseness of the water-bearing deposit and consequent variation in the velocity of subterranean currents eastward. He also suggests the imperfect construction of wells and the consequent subterranean leakage of some wells.

If more weight had been given to this factor his map of pressure and of the limits of the basin would be saved some complexities. Another cause of discrepancies may be hasty or mistaken reading of pressures. Still another, doubtless, is the derivation of waters from different strata. This may perhaps most plausibly explain the lower pressure at Jamestown and Pierre.

The paper is not only of scientific value, but is of such economic utility that we hope it may be issued separately for wider distribution.

J. E. T.

Minéralogie de la France et de ses colonies, tome II, 1re partie. A. LACROIX. Paris, Beaudry et Cie, 1896. 355 pp., numerous illustrations; 15 francs. This work continues the physical and chemical description of the minerals of France, and embraces a study of the geological conditions of their natural occurrences. With this part the work is not concluded, but another part will contain the metals, arsenides, antimonides, the sulphides and sulphates of the different metals. The present fascicle is devoted almost entirely to the feldspars and zeolites. These difficult minerals are defined and distinguished by the new and refined optical methods of the French petrographers as well as by the usual chemical and more obvious physical characters. The work marks a distinct advance in descriptive mineralogy and in petrographical classification.

N. H. W.

Ueber die geologischen Verhältnisse des Cambrium von Tejrovic und Skrej in Böhmen, von JAROSLAV J. JAHN, 10 cuts, 150 p. (Jahrbuch der K. K. geolog. Reichsanstalt, 1895. Bd. 45, Hft. 4, Wien, 1896.) This work is in many respects complementary to that of Dr. Pompeckj, published about a year ago, and reviewed in this journal,* but the present work deals chiefly with the stratigraphy of the Bohemian Cambrian rocks, and that mostly at the localities from which Dr. Pompeckj's collections were made. The different variations of the rock-material, at the special horizons and localities as well as the various species of Cambrian animals is fully set forth in this paper.

Barrande's Etage B is said to contain three terrains; the lowest consists of graphitic clay slates, etc., the second of tufaceous grauwacke associated with various porphyries, and the third a conglomerate and sandstone containing a Lower Cambrian fauna.

Barrande's Etage C is called Middle Cambrian, and contains the Paradoxides fauna. At one locality it shows effusive beds of felsite at two horizons, and has conglomerates at the base and summit, the body of this stage being the well-known Paradoxides slates.

The carefully studied sections of the Cambrian district, described in this article, give very exact knowledge of the horizons at which the several Primordial species of Barrande are found. The indications for depth and habitat of the several species are drawn out at some length, and there is a full table of these species showing their vertical range.

The Paradoxides fauna in Bohemia is not so clearly divisible into sub-faunas as is that of Sweden or eastern Canada. Yet there are really two groupings of the species, the upper of which is found in the red slates of "Pod hruskou" and is marked by the lavigate Agnosti and the dwarfed and aberrant types of the genus Paradoxides. *P. bohemicus* of the Jinec locality will probably belong to this section of the fauna.

The Kammená hürka locality fossils are of a separate fauna and are referred to the Lower Cambrian, and said to be of the Olenellus stage, though no species of Olenellus is named as occurring at the Cambrian localities in Bohemia described by this author.

This paper and Pompeckj's earlier one on the fauna are necessary to those who wish to become familiar with the latest observations on the Bohemian Cambrian rocks. G. F. M.

St. John, N. B., Canada.

Elementary Geology. By RALPH S. TARR. 12-mo, pp. 499, 1897. (New York, The Macmillan Company, Price $1.40.) In looking at this new work, which adds to the already large number of elementary text-books of geology, the first impression is that which is produced by a book excellently published. The publishers have done their share to give it a fair and favorable presentation. The paper is smoothly calendered, and the 283 illustrations, which are well-chosen half-toned engravings from photographs, are well printed. Indeed the book is a pioneer example of what certainly is destined to be the prevalent method of illustrating text-books of natural history. In that respect it is by far in advance of all geological text-books, whether American or European, and it marks an epoch in scientific instruction. This excellence alone, other things being equal, will strongly commend it to teacher and pupil.

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*Die Fauna des Cambrium von Tejrovic und Skrej in Böhmen.

The author is a well-known and competent geologist, the compiler of several other geological text-books. His general grasp of the science is very comprehensive, and his statements flow from his pen with ease and rapidity, in keeping with the familiar and systematic style of the college lecturer. He avoids, in this work, confessedly and properly, the technical parts of geology, and devotes the greater part of the volume to the general principles of structural and dynamic geology. These principles are rapidly and simply placed before the young student, who, with this work as a guide, cannot fail to acquire a love for geology. There is no attempt at fine writing nor poetic sentiment. The pages are overflowing with geological truth, given in simple language. In case something hypothetical is introduced it is distinctly said to be hypothesis. There is no discussion, no hesitancy. The certainties only are put forth. In an elementary work discussion and hypothesis are necessarily excluded.

There are evidences, though but few, of too hasty composition, or at least of too hasty publication after composition, and there are minor errors of statement of fact. All in all, however, the volume is admirably adapted to the purpose for which it is intended, viz., for a text-book for secondary schools, or even for many college classes. It is well adapted for the use of college students that are pursuing classical studies, in the main, but who desire an easy and comprehensive glance at the principles of geology. N. H. W.

Glaciers of North America. ISRAEL C. RUSSELL. Pp. 210, 8vo, 22 plates. (Boston, Ginn & Company, 1897.) This volume puts into the form of systematic description what is known of the principal glaciers of North America, with an introduction giving the principal characteristics of glaciers and their effects on the rocks and the production of the drift. The work is highly instructive and valuable to all who are engaged in glacial geology. Owing to the nature of the subject and the very easy and progressive way in which it is treated by the author, this volume is a good introduction to geology, and many will peruse it with interest if not with wonder as the truths of glacial geology are unfolded to them through its pages. As one after another of the geologic sciences are specialized in text books, the day is near when the great "manuals" will be done away with. To understand glacial geology thoroughly is a good term's work for an ordinary college class, but too often in our colleges not only this, but all stratigraphic and dynamic geology are crowded into one term. N. H. W.

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University Geol. Survey of Kansas, vol. 2, xi and 318 pp., 48 pls., 1897. Introduction to Kansas geology; Physiography of western Kansas, Erasmus Haworth; The Upper Permian and Lower Cretaceous, C. S. Prosser; The Upper Cretaceous of Kansas, W. N. Logan, with an introduction by E. Haworth; The Kansas Niobrara Cretaceous, S. W. Williston; Physical properties of the Tertiary, E. Haworth; The McPherson Equus beds, E. Haworth and J. W. Beede; The Pleistocene of Kansas, S. W. Williston.

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II. Proceedings of Scientific Societies.

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Science, Jan. 29. Cycle in the life of the individual (ontogeny) and in the evolution of its own group (phylogeny), Alpheus Hyatt; Current notes on physiography, W. M. Davis.

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Science, Feb. 19. Lieutenant Peary's expedition, G. H. Barton.

Science, Feb. 26. Earth crust movements and their causes, Joseph Le Conte; The sand-plains of Truro, Wellfleet and Eastham, A. W. Grabau: Current notes on physiography, W. M. Davis; Former extension of Greenland glaciers, R. S. Tarr.

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Thomas Tracy Bouvé, memorial meeting. Boston Soc. Nat. Hist., vol. 27, pp. 219-241, Dec., 1896.

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Marine fossils from the Coal Measures of Arkansas, J. P. Smith. Pp. 1-72, pls. 16-24; reprinted Jan. 7, 1897, from Proc. Amer. Phil. Soc., vol. 35, no. 152.

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Administrative reports of the Iowa Geological Survey, Samuel Calvin, A. G. Leonard, W. H. Norton. Iowa Geol. Survey, vol. 7, pp. 9-31, 1897.

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Note on the ventral armoring of Dinichthys, Bashford Dean. Ibid., pp. 57-61, pls. 2-3, Jan. 25, 1897.

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Johns Hopkins Univ. Circulars, vol. 16, no. 128, Feb. 1897. The geology of the Sand hills of New Jersey, W. B. Clark and G. B. Shattuck; The principles involved in projecting panoramic views from contoured maps, Josiah Pierce. Jr.

Bull. of Amer. Paleontology, vol. 2, no. 7, 109 pp., Feb. 10, 1897. A bibliography of the geological, mineralogical and paleontological literature of the state of Virginia, T. L. Watson,

Field Columbian Museum, Annual Exchange Catalogue for the year 1896-97. 57 pp., Nov., 1896.

INTERNATIONAL GEOLOGICAL CONGRESS.

SEVENTH SESSION, RUSSIA, 1897.

SECOND CIRCULAR.

As a supplement to our first circular, sent in the spring of 1896, we have the honor of submitting to you the following details concerning the duration of the 7th session of the International Congress at St. Petersburg, and the excursions that it is proposed to organize before and after the session.

The sessions of the Congress will take place at St. Petersburg from the 17th (29) of August to the 22d of August (4th of September) in the building of the Imperial Academy of Science. In regard to the programme occupying the time of the Congress, the committee of organization has placed itself in communication with the president and secretary of the permanent committee, established by the session at London, and charged with the duty of preparing the questions that it will be desirable to submit for discussion. As soon as the programme shall be definitely determined upon we shall take care to address it, by circular, to all the geologists.

As we have already had occasion to say in our first circular, a special hall will be assigned to all the exhibits of catalogues, maps, profiles, editions, collections, etc. The committee of organization, after an understanding with the Minister of Finance, takes pleasure in announcing that all the objects intended for exhibition bearing the address, "Russia, St. Petersburg Exposition of the International Geological Congress," without having been submitted to any customs inspection on the frontier, can come to St. Petersburg, where they will be unpacked in the presence of persons designated by the committee. To facilitate the formalities of viséing the passports of geologists coming to the Congress, the committee of organization has placed itself in communication with the Minister of Foreign Affairs, who has instructed all the Russian consuls in foreign countries to ameliorate, in favor of each of the geologists who participate, the formalities of the visé on the presentation of the membership card of the Congress. At the passage of the frontier it will suffice to exhibit the same card to the employés of the custom house, who have been ordered to facilitate as much as possible the formalities of the custom house.

All geologists who shall have paid the amount of their membership fee will receive a personal ticket giving them the right to gratuitous first-class transportation over the Russian and Finland railroads. Taking into consideration that these tickets must be prepared and forwarded in time, the Committee of organization begs those persons desirous of taking part in the Congress to pay their membership fee before the 13th (27th) of March of the present year.

The membership fee giving the right to participation in the Congress has been fixed at 5 roubles=10 marks=12 francs=10 shillings. This sum should be addressed to the name of the treasurer, A. O. Michalski, geologist of the Geological Survey, (Geological Survey, St. Petersburg Wassilli Ostrov 4th line).

Each of the members of the Congress will ultimately receive the work which is printed of the proceedings of the Seventh Session of the International Congress.

The definite programme of excursions which will be undertaken, some before as well as after the session, has been arranged as follows:

I. EXCURSIONS BEFORE THE CONGRESS.

A. Excursion to the Ural.*

The directors of the excursions will be: Of that of the 16th (28th) of July to the 22d of July (3d of August), S. Nikitin. Of that of the 22d of July (3d of August) to the 31st of July (12th of August), Th. Tschernyschew. In the Mineral Mines from the 29th of July (10th of August) to the 30th of July (11th of August), A. Arzruni. From the 31st of July (12th of August) to the 5th (17th) of August, A. Karpinsky. From the 6th (18th) of August to the 8th (20th) of August, Th. Tschernyschew. From the 10th (22d) of August until the arrival at Nijni-Novgorod and St. Petersburg A. Stuckenberg and S. Nikitin. Meeting of the excursionists at Moscow the 17th (29th) of July.

Persons desiring to take part in the excursion in the environs of Moscow before the opening of the Congress are invited to meet on the morning of the 16th (28th) of July at Moscow, where it is proposed to make the following excursions: On the 16th (28th) of July visit to the Kremlin and to the mountains of Worobiowy (mountains of the Sparrows).

17th (29th) of July, Dorogomilowo and Mniowniki.

18th (30th) of July, Miatchkowo.

18th (30th) of July, evening, departure from Moscow by the railroad of Riazan.

19th (31st) of July, in the morning, Riajsk.

20th of July (1st August), morning, Syzran. Excursion in the environs of Syzran.

21st of July (2d of August), Samara; trip to Tzarow-Kourgan and to the mountains Jégouli. In the night, departure from Samara.

22d of July (3d of August), stop at Slak or Dawlokanowa. At noon, departure for Oufa. Sections of Oufa. In the night, departure from Oufa.

23d of July (4th of August), Station Acha. From there on foot or by railway, but with stops, to the Station Miniar. The night will be passed at Miniar.

24th of July (5th of August) from Miniar to the station Simskaïa, and from there on horseback to the works of Simsk and vicinity of the works. Return to Simsk.

25th of July (6th of August), from the Station Simskaïa by Yéral and Yakhia to Oust-Kataw. (The journey from Yakhia to Oust-Kataw will be made on foot.) Stop at Oust-Kataw.

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*Those taking part in the excursion to the Urals, having to make considerable journeys in open carriages, will do well to provide themselves with strong impermeable boots, warm clothing and water proof overcoats.

26th of July (7th August), Oust-Kataw to the Wiazowaïa; from there on horseback to the mine of Bakal, where the night will be passed.

27th of July (8th of August), examination of the strata of Bakal. In the evening on horseback to the works of Satka, and from there to the station Souléïa. Trip to the landing of Satka (if weather permits).

28th of July (9th of August), from the station Souléïa to Slatooust. Examination of the sections of Kossotour; examination of Ourenga.

29th of July (10th of August), excursion to the Great Taganaï (Bolchoï Taganaï).

The geologists desirous of visiting the Mineral Mines will make this a special excursion.

30th of July (11th of August), trip to the works of Koussa.

31st of July (12th of August), departure from Slatooust across the Urals. Stop at the station Ourjoum; visit to the mountain Alexandrowskaïa Sopka. From there to Mias, visit to the placers. Stop at Mias.

1st (13th) of August, mountains of Ilmen and journey to Tcheliabinsk. A small group of excursionists will leave the station Bischkil to visit, under the direction of N. Wyssotsky, the gold deposits of Katchkar.

2d (14th) of August, trip to the mine of Wonliarlarski, and visit to the mines of Podwintsew and of Zélenkow of the system of Katchkar. Kychtyn.

3d (15th) of August, Mt. Sougomak.

4th (16th) of August, Kychtym Ekatherinebourg. Visit to the Imperial factory for cutting stones.

5th (17th) of August, excursion will divide itself into two groups; the one will visit the gold mines of Bérézowsk, and the other will cross lake Werkh-Issetzky in a steamboat, arriving at the village Palkina (under the direction of O. Clerc). Visit to the mineral deposits of Eugenie-Maximilianovna (under the direction of A. Karnojitsky).

6th (18th) of August, from Ekatherinebourg to Tagil. Mountain Wyssokaïa.

7th (19th) of August, visit to the copper mines. Miédnoroudniansky and to the mountain Lyssaïa. From Tagil to the manganese mines.

8th (20th) of August, in the morning from Tagil to Barantcha. Trip to the mountain Sinaïa. Journey to Kouchwa. Mountain Blagodat. The night will be passed at Kouchwa.

9th (21st) of August, from Kouchwa to the Urals by a branch road from Louniévskaïa to the works of Alexandrovsk. The night will be passed at Perm.

10th (22d) of August, from Perm descent of the Kama.

11th (23d) of August, the mouth of the Biélaia.

12th (24th) of August, Laïchow.

13th (25th) of August, Kazan. Reception at Kazan. Visit to the city and University. In the night the party will leave Kazan and arrive the next morning early at Koznodémiansk.

14th (26th) of August, voyage to Nijni-Novgorod.

15th (27th) of August in the evening or

16th (28th) of August in the morning, arrival at St. Petersburg.

B. Excursion in Esthonie.

From St. Petersburg to Reval, to the Baltic port, along the Baltic railway, to the island of Dago.

The excursion will be under the direction of Fr. Schmidt and will extend from the 1st (13th) to the 15th (27th) of August.

C. Excursion in Finland.

Under the direction of I. Soderholm and W. Ramsay.

Meeting of the excursionists at Holsingfors the morning of the 9th (21st) of August.

Departure for Tammerfors the evening of the 9th (21st) of August, where the night will be passed.

10th (22d) of August, excursion in steamboat to examine the shores of lake Näsijärvi. The night will be passed at Tammerfors.

11th (23d) of August, by railroad to Siuro; from there on horseback to Lavia. The night will be passed at Lavia.

12th (24th) of August, from Lavia to Tammerfors. The night will be passed at Tammerfors.

13th (25th) of August, excursion in the environs of Tammerfors. Departure for Lahtis, where the night will be passed.

14th (26th) of August, excursion to Hessilä and return to Lahtis. Departure for Kotka, where the night will be spent.

15th (27th) of August. In the morning, departure for Hogland. Return to Kotka, and departure for Wiborg, where the night will be passed.

16th (28th) of August. In the morning arrive at St. Petersburg.

16th (28th) of August, preliminary meeting of the members of the Congress.

17th (29th) of August). opening of the Congress.

23d of August (4th of September), closing of the Congress.

II. EXCURSIONS AFTER THE CONGRESS.

Excursion to the Caucasus*

Departure from St. Petersburg the 24th of August (5th of September) in the evening.

25th of August (6th of September): Arrive at Moscow, and stay at Moscow. From the 25th the 27th of August (6th to the 8th of Sept.), repetition of the excursions in the environs of Moscow for the persons who desire to take part. (See first three days of the Excursion to the Urals, Kremlin, Worobiowo, Dorogomilowo, Mniowniki and Miatchkuwo.)

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*The excursion to the Caucasus, without stop, in the center and southern part of Russia, will not be undertaken on account of the small number of geologists who have expressed their desire to take part in it.

DEPARTURE FROM MOSCOW IN THREE GROUPS.

GROUP A.

(Directors: 28th of August (9th of Sept.) S. Nikitin; 29th of August (10th of Sept.) A. Gourew; from the 30th of August (12th of Sept.) to the 1st (13th) of Sept.) Th. Tschernyschew and L. Loutougin: 2d (14th) of Sept., K. Rouguowitsch for the first section, A. Konchin for the second.)

28th of August (9th of Sept.). Departure from Moscow in the morning. Stop at Podolsk, Toula and Aleksine. The night at Koursk.

29th of August (10th of Sept.). Kharkow. Stop at Kharkow. Departure at night from Kharkow.

30th of August (11th of Sept.). Basin of the Donots, Wolyntzowo. Mercury mine, Corlovka. Departure at night to Rostow.

1st (13th) Sept. Rostow.

2d (14th) of Sept. Mineral Springs.

The excursionists will divide themselves into two sections. The first will go to Kislowodsk, visiting, in passing, Jéliéznowowdsk, Piatigorsk, and Essentouki.* The other will continue its road to Grezny for the purpose of visiting the petroleum springs near this station.

3d (15th) of Sept. Wladikavkas.

GROUP B.

(Under the direction of A. Pavlow and of W. Amalitzky.)

26th of August (7th of Sept.) Departure in the evening from Moscow to Nijni-Novgorod.

27th of August (8th of Sept.) Examination of the sections of Nijni-Novgorod. Departure in the evening from Nijni-Novogored.

18th of August (9th of Sept.), Kazan.

29th of August (10th of Sept.). In the morning, Dalinowka (on the frontier of the governments of Kazan and of Simbirsk Gorodichtché, and region above Poliwna). In the evening the party will pass in front of Simbirsk.

30th of August (11th of Sept.). Chiriaïowbouérak asphalt quarries, ascending from the bridge. Kachpour below Syzran.

31st of August (12th of Sept.). In the morning, stop below Wolsk. Stop opposite Boronsk. About evening, arrive at Saratow.

1st (13th) of Sept. In the morning, stop near Bannovka. During the day, stop near Chtcherbakovka. In the evening, arrive at Kamychin.

2d (14th) of Sept. Stop near Balykléï. The same day arrive at Tzaritsyn, from Tzaritsyn either by rail across to Wladikavkaz or by steamboat via Astrakhan and Petrovsk and Wladikavkaz.

GROUP C.

(Under the direction of N. Sokolow.)

27th of August (7th of Sept. Departure in the evening from Moscow by the express train to Kiew.

28th of August (9th of Sept.). Arrival in the evening at Kiew.

29th of August (10th of Sept.). Examination of the Tertiary and post-Tertiary deposits of Kiew and of its environs.

30th of August (11th of Sept.). Departure from Kiew in steamboat for Tchorkassy. In the evening from Tchorkassy to Znamenka.

31st of August (12th of Sept.) Nikolaïow. In the morning, by steamboat to Khorson. Visit to the environs of Khorson.

1st (12th) of Sept. From Kherson te Nikopel and from there to Alexandrovsk.

2d (14th) Sept. Trip to Konka (if the weather permit.) The same day departure from Alexandrovsk for Rostow, to Wladikavkaz, where the party will arrive about the evening of the 4th (16th) of September.

From the 4th (16th) to the 7th (19th) Sept. the three groups reunited will proceed by the military road of Georgia to Tiflis. under the direction of F. Loewinson-Lessing. A small group will detach itself at Wladikavkaz and under the direction of B. Kelenko, will go to the glacier Guénaldon, returning to the military road of Georgia the 7th (19th) of Sept. and continuing the journey to Tiflis.

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*The persons who will visit Elborous will separate at Kislowodsk. The excursion to Elborous will be made on horseback, and will take about four days. The party will sleep in tents. The participants will rejoin the other part of the excursion at Tiflis.

Reunion of all the excursionists at Tiflis and departure, the 9th (21st) Sept. for Bakou, under the direction of A. Konchin and J. Sjögren.

The 10th (22d) and 11th (23d) Sept. at Bakou.

Departure on the evening of the 11th (23d) Sept. from Bakou in the direction of the Station Souram. There the excursionists *will divide* themselves into two groups:

The principal group, under the direction of S. Simonowitch, will go from the station Souram Biélogory, partly on foot and partly by railway, and will pass the night of the 11th, (24th) Sept., at Biélogory. The 13th (25th) Sept. Journey from Biélogory to Tkwiboul, where the night will be passed.

The 14th (26th) Sept., visit to the environs of Tkwiboul.

The 15th (27th) Sept., from Tkwiboul to the station Rion.

The smaller group will proceed under the direction of A. Konchin, from the station Mikhaïlowo to Borjom, where it will pass the night.

On the 13th (25th) Sept., journey on horseback from Borjom to Abas-Touman. The night will be spent in Abas-Touman.

The 14th (26th) and 15th (27th) Sept., the journey from Abas-Touman to the station Rion will be made with a halt on the road to pass the night.

The excursionists who desire to take part in the general excursion to the Crimea will meet at the Station Rion.

N. B. The geologists who desire to take part in a special excursion to the glacier Mamisson, under the direction of S. Simonowitch will detach themselves at the Station Rion and will remain in the Caucasus seven days longer; they will not arrive in the Crimea until towards the end of the general excursion. The 15th (27th) September in the morning the persons who will participate in the excursion to the Crimea will meet at Batoum, leaving in the evening on a steamboat for Kertch, where they will arrive the morning of the 17th (29th). The entire day of the 17th (29th) Sept. will be devoted to the visit to the environs of Kertch under the direction of N. Androussow. Departure at night in steamboat from Kertch.

The 18th (30th) Sept., Koktebel. Excursion on foot, under the direction of A. Lagorio, to Karadag. Departure that evening in steamboat to Soudak.

19th Sept. (1st October). Excursion to the environs of Soudak under the direction of K. von Vogdt. At Alouchta the excursionists will divide into two groups for the afternoon.

The first group (under the direction of K. von Vogdt) will proceed in steamboat to Yalta.

The 20th Sept. (2d Oct.) visit to Aloupka and to Yalta.

The 21st Sept. (3d Oct.), journey in steamboat from Yalta to Sebastopol.

The 22d Sept. (4th Oct.), visit to the environs of Sebastopol.

The second group (to the number of 60 persons at the most) under the direction of A. Colovkinsks, will remain at Alouchta, where it will pass the night.

The 20th Sept. (2d Oct.), partly on foot, partly in carriages, it will proceed to Yalta, visiting Kastel, Biyouk-Lambat, Aïyoudag, etc.

The 21st Sept. (3d Oct.) crossing of the mountain by the new road, passing by Yaïla, arriving at Bakhtchissaraï.

The 22d Sept. (4th Oct.), excursion to the environs of Bakhtchissarī. In the evening, on horseback to Sebastopol.

The 23d Sept. (5th Oct.) reunion of all the excursionists at Sebastopol.

END OF THE EXCURSION.

A guide of the excursion is being printed at this moment, provided with a geological map of Russia on a scale of 1 to 6,300,000 (150 versts to one English inch), and with numerous special cards, profiles, and figures. The members of the Congress may receive this guide, that is to say at the latest by the end of April, on payment of ten francs.

The committee of organization which has taken all possible pains to diminish as much as possible the expense of the excursion to the Ural, has fixed the price at 150 roubles (400 francs), including subsistence from the departure from Moscow to the return to St. Petersburg. This price could be secured only thanks to the personal effort of the Minister of Agriculture and of the domains of the Empire, his excellency A. Yermolow, to whose jurisdiction the Geological Survey of Russia belongs; thanks also to the proprietors and to the administration of the districts having works and to the kindness of the administration of some of the cities lying along the route of the excursion, which have been pleased to grant the largest hospitality.

The excursion in Esthonie will cost 50 roubles (135 francs). That in Finland is estimated at 50 Finland marks (50 francs.)

The expense of the great excursion after the Congress (see the three variations, but not comprising the excursion to Ararat, to the glacier Mamisson, and to Elborous) will amount per person to 250 roubles (665 francs). The persons who desire to make but one part of the general excursion to the Caucasus and in the Crimea, and similarly those who will remain in the Caucasus to take part in the special excursion to Ararat and to the glacier Mamisson, will have to pay 8 roubles (21 francs) for each day passed in the general excursion. The excursion to Ararat will cost 100 roubles (270 francs) per person.

The special excursion to the glacier Mamisson will cost 45 roubles (120 francs).

The participants in the excursion to Elborous will pay 15 roubles (40 francs) besides the expense of the principal excursion.

The excursion from Yahta to Sebastopol by Bakhtchissaraï will cost 15 roubles (120 francs) in addition to the expense of the principal excursion.

In determining the amount of the expense of the excursions, the committee on organization deems it a duty to add that in case these expenses should be less, each of the excursionists will receive the part which comes to him after the verification of the sums which have been expended.

In the name of the general committee of organization.
The Bureau,
A. KARPINSKY, *President*,
TH. TSCHERNYSCHEW, *General Secretary*.

CORRESPONDENCE.

Moraines of Recession and their Significance in Glacial Theory.* The Wisconsin stages of glaciation shows fifteen terminal moraines in consecutive series in the interval between Cincinnati and the straits of Mackinac, and three more farther north probably belonging to the same series. The count of moraines was made in the axes of a connected series of open valleys and on the lake shore where the oscillation of the ice-front was freest and its amplitude greatest. With due consideration of topography and its influence on ice-motion, it seems apparent that the series is completely representative of all the oscillations which the ice-front underwent in retreating over this interval, and further, that the oscillations were distinctly of a periodic nature and that the periodicity affected a wide area. The oscillations of the ice-front is attributed to climatic oscillation and this, it is thought, can be ascribed only to an astronomical cause. Theoretical considerations and also the best conclusions deducible from recent observations in Greenland by Chamberlin, Salisbury and others, indicate a very slow rate of motion for the ice-sheet. And further, the same theoretical considerations and observations indicate that nearly all the drift transported by the ice-sheet was carried englacially, but that the load of debris in transport in a given section of the ice was quite small. On these grounds the annual and thirty year periods of climatic oscillation are rejected as far too short. It is believed that the building of a terminal moraine five miles or more wide and 50 to 300 feet or more high required hundreds or probably a few thousands of years. The imbrication of the drift, the form of the simplest moraines, and other phenomena show that the moraines were generally, if not always, built after a re-advance of the ice. The oscillations of the ice-front were like those which would be produced by the precession of the equinoxes through its influence on climate. This, therefore, is taken as the probable, but not the certain cause. The average period of precession is 21,000 years. Its extreme minimum is 10,500 years. The minimum is believed to accord well with the evidence, but the average seems rather long.

While the oscillations were going on there was a greater and much slower change of climate in progress. The regularity of the moraine series proves the extreme slowness and regularity of this greater change—whether its rate was uniform or varied slowly in a uniform way. The latter mode is indicated by the facts, and this too, then, as it seems to the author, has a distinctive character which can be ascribed only to an astronomical cause. The oscillation of the ice-front and also the greater climatic change that caused the epoch of glaciation are both astronomic in quality. Croll's hypothesis, even with Bell's modification, is not thought to be a satisfactory explanation.

F. B. Taylor.

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*Abstract of paper read at Washington, December, 1896.

PERSONAL AND SCIENTIFIC NEWS.

Professor C. H. Hitchcock, of Hanover, N. H., is about to organize another expedition to Greenland for the summer of 1897, with Lieut. Peary. The cost per man, last year, was $500, and it is expected to be about the same this year.

New Mine Inspector in Kentucky. Governor Bradley has appointed G. W. Stone, a lawyer and a politician, who "warmly supported governor Bradley in his race for governor in 1895," to the position of mine inspector of Kentucky. Such positions, requiring the knowledge and skill of a practical geologist, ought to be exempt from the spoilsman's control.

Governor Tanner, of Illinois, through the inscrutable ways of political magic, has converted a steamboat agent into a geologist. In other words, he has appointed Mr. C. H. Crantz, state geologist and curator of the state museum at Springfield. When the office of state geologist falls into the position of a politician's football, its questionable usefulness is exemplified by the history of Indiana and Illinois for the last few years.

The American Institute of Mining Engineers held its seventy-second meeting in Chicago, beginning Tuesday, Feb. 16th. The following papers, relating more or less to geology, were read:

The geology of the magnetites near Port Henry, N. Y. *J. F. Kemp.*
The manganese deposits of Panama, *E. J. Chibas.*
The Chicago drainage canal. *J. F. Lewis.*
The genesis of auriferous lodes from a chemical point of view. *J. R. Don.*
The cement materials of southwestern Arkansas. *J. C. Branner.*
The Chromite deposits on Port au Port bay, Newfoundland. *G. W. Maynard.*
Faulting in glacial gravels. *W. S. Gresley.*
A Nova Scotia copper deposit. *Henry Lewis.*
The Potsdam gold ore of the Black Hills. *F. C. Smith.*

Geological Section of the New York Academy of Sciences, February 15, 1897. The first paper of the evening was by Mr. F. C. Nicholas, and was entitled "Explorations in the gold fields of western Columbia."

Mr. Nicholas described the curious placers in western Columbia, which, while extremely rich in limited portions, are of very low grade when considered as extended propositions. The gold gravels occur along the western base of the Andes mountains and extend from the gulf of Darien southward up the Atrato river to Quibdo. They are also found to the southward of the San Juan river, and are in the form of terraces similar to the terraces of the Atlantic states. The surface geology indicates that the gulf of Darien formerly extended a long distance up the valley of the Atrato. Quite detailed descriptions of the valleys and of the character of the terraces were given in the paper. Mr. Nicholas described a route by which a man could sail in a canoe from the Atlantic to the Pacific, in the wet season, by going up the Atrato river to the Quito river, thence to the divide, which is a series of swamps, thence into the San Pablo river and so down the San Juan to the Pacific.

The second paper of the evening was by Prof. R. E. Dodge entitled "Recent work in Physiography."

Professor Dodge gave an outline of De Lapparent's "Leçons en Géographie Physique," of Sir John Bullock's "Scenery of Switzerland," and of two recent papers, one by M. R. Campbell, entitled "Drainage Modifications and their Interpretation," the other by C. F. Marbut on "The Physical Features of Missouri."

The last paper of the evening was by A. A. Julien on the "Sculpture and Sorting of Sands."

The speaker, by means of lantern slides, illustrated various varieties of sand, and their chief methods of origin and their compositions. After citing the schemes for the classification of sands advanced by Zirkel and Daubrée, he gave one of his own, which was more elaborate and was partly based on the methods of origin and partly on the physical characters.

J. F. KEMP, *Secretary.*

March 15, 1897. The first communication of the evening was by Mr. Heinrich Ries entitled "Mineralogical Notes."

Mr. Ries spoke of some allanite crystals with new faces; also of some large crystals of fibrous gypsum from Newcastle, Wyoming: also exhibited some large childrenite crystals from Maine and some amphibole crystals with many terminal faces from Virginia. He also spoke of some pseudomorphs of gold after sylvenite from Cripple Creek, Colorado. The finding of a new beryl crystal with an unusually large number of terminal faces in New York city was also noted,

The second paper of the evening was written by Mr. Herbert Bolton, entitled "The Lancashire Coal Field of England," and read in abstract by president Stevenson.

The paper spoke of the geographic conditions of the Lancashire coal field and its neighborhood, of the extent and quality of the coal and of the age of the structural movements which had caused the present geological characteristics in the coal area. A careful correlation was made between the coal measures of this field and the deposits of the United States. Distribution of the fanua and flora and their character was taken up in some detail and it was shown that in the lower coal measures the life is mostly marine, in the middle coal measures of fresh and brackish origin, and in the upper coal measures that the fauna was scarce. When published this paper will be a valuable contribution to the literature of coals and will be of great assistance to workers in America in their endeavors to correlate the deposits on the two sides of the water.

The third paper of the evening was by Stuart Weller, of Chicago University, entitled "The Batesville Sandstone of Arkansas," abstracted by Mr. Gilbert Van Ingen.

The paper entered into some detail regarding the Batesville section and the fauna of the Batesville sandstone in that section. Of the invertebrates thirty species have been found, of which eleven point to the St. Louis age of the sandstone, six to the Kaskaskia age, while thirteen are of indeterminate value. On account of the greater abundance of the numbers of specimens of the second group and from stratigraphic evidence as well, it is probable that the sandstone belongs in the base of the Kaskaskia group and is the same as the Aux Vasa limestone of southern Illinois. This paper gives the data wherewith to correlate the Mississippi section with the section about the Ozark hills.

RICHARD E. DODGE, *Secretary.*

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THE

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CHANGES OF LEVEL IN THE BERMUDA ISLANDS.

By RALPH S. TARR, Ithaca, N. Y.

(Plates XVI, XVII, XVIII.)

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Scope of the Article. The actual field work upon which this paper is based occupied about two weeks in March, 1896, during which time a large portion of the islands was examined. In the course of this study some points in the history of the islands were developed, and it is this that gives excuse for the preparation of the paper. At the same time, the study also led to other conclusions which had previously been reached by workers in the field. Since the verification of another's work has a certain value, and since the statement of these other conclusions is necessary in order to make clear the bearing of the new observations, the article is made to cover the important facts in the development of the Bermudas, so far as these are revealed by the topography and stratigraphy. Hence the new observations form only a part of the article, the remainder being a summary statement of the history as developed by others and as verified by my own studies.

Conclusions Reached by Previous Observers. A number of workers have been in the Bermuda field, and although upon some points there is now quite uniform agreement, there is at the same time a considerable variety of opinion expressed in the published papers.

The first article descriptive of the geology of the Bermudas is by Nelson.* He points out the fact, to which all later workers agree, that the Bermudas are composed of sand derived from the grinding of coral and other calcareous fragments, by the waves, and then accumulated by the wind into the form of sand dunes, thus constituting the present islands of Bermuda. He also recognizes a different kind of rock, harder and more dense, underlying parts of the island, to which he gives the name *base rock*.

Rein (Bericht ü. d. Senckenbergische Naturf. Gesellschaft, 1870, p. 140) has described the geology of Bermuda, but I have not been able to obtain his article.

Jones† brings forward evidence of submergence of the Bermudas to a depth of not less than 48 feet. This is proved by excavations and borings made by the government in connection with the construction of the great naval dock yard on Ireland island. This evidence is obtained from the discovery of vegetable remains at the depth of 48 feet below the present sea-level. He argues from other evidence that this submergence of 48 feet is merely the minimum. The same author has published other papers concerning the geology of the Bermudas.‡

Wyville Thomson visited Bermuda during the voyage of the Challenger and published a description of some of its features.§ Among other things he says that there is really only one kind of rock in the Bermudas, namely the consolidated æolian sand described by Nelson. He mentions the base rock but says that it does not occur everywhere beneath the islands. He gives a section (p. 319), made at the dock yard at Ireland island, in which the irregular surface of the base rock is shown to underlie the peat beds previously described by Jones. Descriptions are also given of the present encroachment of sand dunes upon parts of the island and a very complete description of the caves. The author previously* published some of the facts which were later described in more detail in "The Atlantic."

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*Trans. Geol. Soc. London, 2d Ser., V, 1840, 103-123.

†Nature. VI, 1872, 262.

‡Jones, The Naturalist in Bermuda, London, 1859; also Visitor's Guide to Bermuda. Articles by Jones have also appeared in the Proc. and Trans., Nova Scotia Inst. of Nat Sci. Neither of these descriptions has been accessible, and hence I can make no further reference to them.

§The Atlantic, vol. I, 1877, 290-347.

A much more exhaustive account of the geology of the Bermudas is presented by Rice.† He mentions the discovery of peat beds in the center of the main island at depths of 40-50 feet below the surface. His article contains a very complete description of the difference between the base rock and the æolian sand rock and he believes that the base rock proves subsidence. The upper limit of the base rock above the sea is found to be about 15 feet, where it is overlaid by wind-blown sand dunes containing land shells. He states that there is no evidence that this base rock is essentially older than the æolian.

The movements which Rice has determined are as follows: "1. A subsidence, in which the original nucleus of the islands disappeared beneath the sea, the characteristic atoll form was produced and the now elevated beach-rock was deposited. 2. An elevation, in which the great lagoon and the various minor lagoons were converted into dry land, and the vast accumulations of wind-blown sand were formed, which now constitute the most striking peculiarity of the islands. 3. A subsidence, in which the soft drift-rock around the shores suffered extensive marine erosion and the shore platform and cliffs already described were formed."‡

Fewkes§ admits local subsidence of the æolian hills, but argues that the present outline of the islands is mainly due to erosion. He brings forward many facts showing marked erosion.

In his Bermuda Islands, Heilprin‖ discusses the zoology and geology of the islands. His conclusions (p. 46) concerning the history of the islands are as follows: the present land area was formed during a period of elevation, during which the entire archipelago was apparently a connected piece of land. The elevation was probably not less than seventy or eighty feet, and may have been considerably more. The elevation was followed by a subsidence of at least 60-70 feet causing the lagoons and sounds.

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*Nature, VIII, 1873, 266-267, and also XIV, 1876, 97.

†Bull. U. S. Nat. Museum, No. 25, vol. I, 1884, 1-32.

‡Bull. U. S. Nat. Mus., No. 25, vol. I, 1884, p. 16.

§Proc. Boston Soc. Nat. Hist., XXIII, 1884-1887, 518-522. AM. GEOL., V, 1890, 88-100.

‖The Bermuda Islands, Heilprin, Philadelphia, 1889.

The last description of the Bermudas is that of Alexander Agassiz.* He accepts the æolian explanation for the hills and the theory of subsidence to account for the present dissected condition of the islands. He also believes in much erosion, but in the base rock he finds no proof of former greater elevation as Rice has argued. He therefore holds to a single subsidence of the land since the formation of the sand hills.

General Features of the Islands. The Bermuda islands, one or two hundred in number, are clustered together in a group, curved somewhat in the manner of a fish-hook. The length of the archipelago is about fifteen miles and the width about three. In size they vary greatly from the irregular, deeply indented main island, whose area is about 10,000 acres, to tiny rocks in the sea. The greatest elevation above sea level is about two hundred and fifty feet, and a number of hills rise to the elevation of more than one hundred and fifty feet above sea level.

This group of islands is situated upon the nearly level top of a peak which rises from the sea bottom, whose depth is twelve to fourteen hundred fathoms at a distance of only eight or ten miles from the edge. The peak has the form of a volcanic cone, which probably it is, smoothed over at the top. The shallow top of the peak is a reef-covered and somewhat irregular shoal, elliptical in outline, with diameters of about twenty-five and twelve miles. The depth of water upon this shallow, reef-like plain is rarely over eight or nine fathoms. The islands which are set upon this are mainly clustered at the southern and southeastern side of the shoal. South of this are two other banks smaller in area, but deeper below the surface of the sea.

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*Bull. Mus. Comp. Zool., XXVI, No. 2, 1895, 209-281. A shorter statement of the same observations was made in the Amer. Journ. Sci., XLVII, 1894, 411-416.

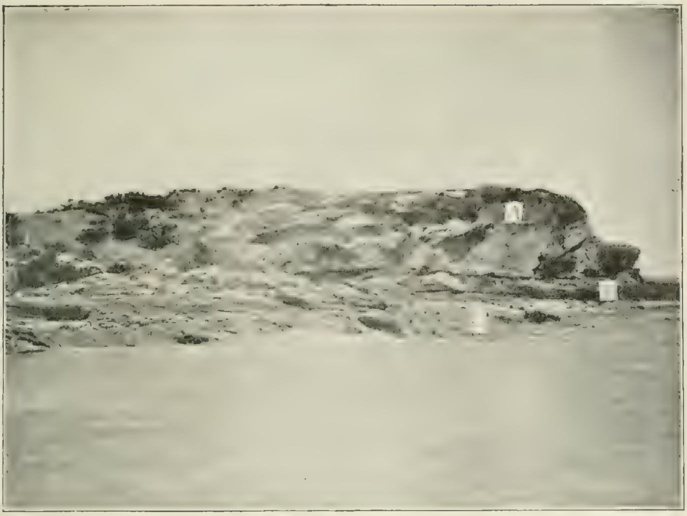

FIG. 1.—UNCONFORMITY ON NORTH SIDE OF DEVON BAY. A, ÆOLIAN ROCK; B, BEACH BED; C, BASE ROCK.

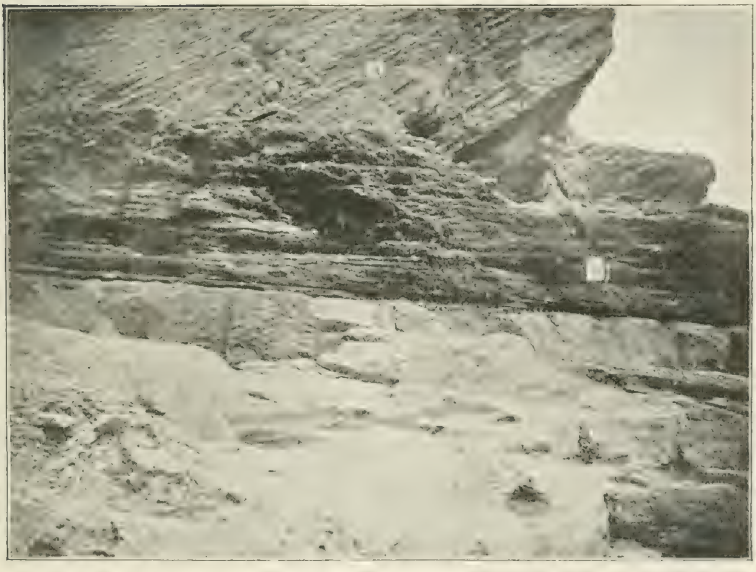

FIG. 2.—NEAR VIEW OF A PART OF FIG. 1. A, ÆOLIAN ROCK; B, BEACH ROCK; C, BASE ROCK.

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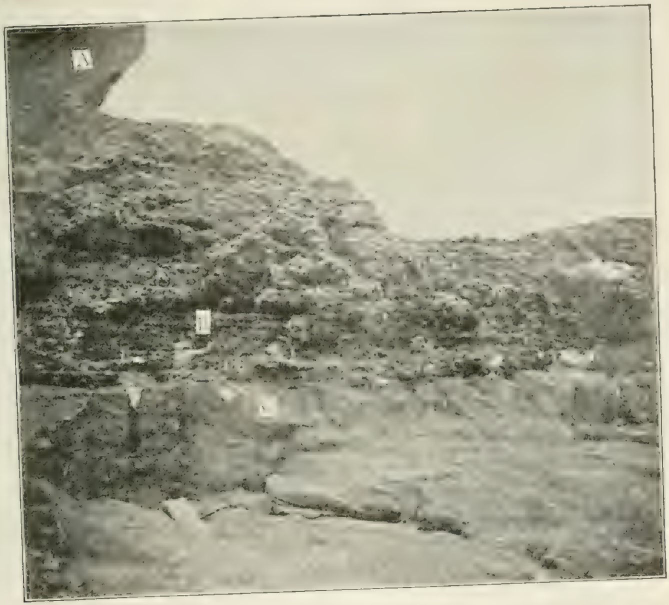

Fig. 3.—Shell-bearing layer (B) of beach rock, beneath æolian beds (A) and resting on base rock (C).

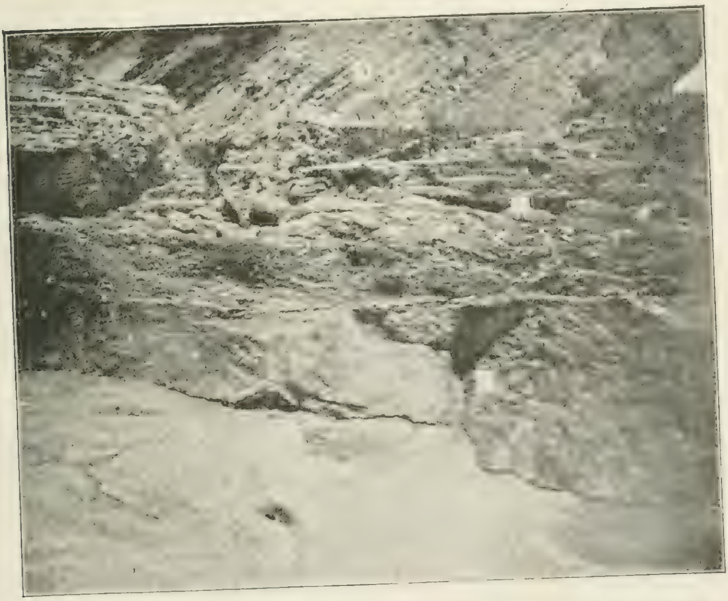

Fig. 4.—Pebble-bearing beach rock (B) on base rock (C) and beneath æolian beds (A).

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In structure the Bermudas are mainly composed of wind-blown shell and coral sand, confusedly thrown together in the manner common to æolian deposits. The wind-drift structure of the consolidated coral sand is everywhere apparent, in road-cuts, in quarries and sea cliffs, as well as upon the outcrops in the fields. This is one of the most noticeable features of the geology of the islands. Not only is the evidence of the æolian origin distinct, but the process of dune formation may still be seen along the south shore, where the shell fragments, ground to bits on the beach, are moving inland over the surface of the islands.*

While the greater portion of the islands which rise above the sea, is made of wind-blown shell sand, it is equally certain that in a number of places this rests on a pedestal of denser rock, the "base rock," which is older and much more compact than the sand hill rock. This base or beach rock may be seen at various places beneath the cliffs of the south shore, and it was also discovered in the boring at Ireland island. Where in contact with the sand rock its surface is very irregular,† but in no place was it seen to a hight greater than fifteen feet above the sea. In other places it appears to be absent, although, as in the case of Ireland island, it may still be present at some distance below the sea level. While consolidated layers of the blown sand are generally soft and crumbly, the beach rock is always dense and hard, ringing under the hammer, like some even-grained igneous rock.

Accumulation of the Base Rock. As Rice has so satisfactorily proved, this dense stratum was accumulated under beach conditions. Its counterpart in unsolidified form is now to be seen on the various beaches of the south shore. The texture of the grains composing it is distinctly coarser than that of the wind-blown deposits, and in it may be seen innumerable fragments of shells and corals which have been ground up by the waves. A prolonged search failed to discover any layers containing fossils sufficiently perfect for identification. Of the fragments obtained, only a few were in such condition as to warrant specific determination, and these were species which might be found either in Recent, Quaternary or even late Tertiary beds. Hence it has not been possible to determine the exact age of this bed, the oldest of the Bermuda rocks.

---

*These dunes have been described by previous observers, and a photograph of a house partly buried beneath the encroaching sand, was taken by Thomson, and published in "The Atlantic" (p. 312). The view shows the chimney and a part of the roof projecting above the sand. At the time of my visit the chimney was nearly covered: and a photograph then taken, showed very decided increase in the sand accumulation. However, by the growth of oleanders and other trees, the sand movement is now nearly checked.

†This is well seen in Thomson's section, The Atlantic, vol. I, p. 319.

Unconformity at the Top of the Base Rock. This layer of base rock outcrops at various places along the south shore, and reaches different elevations, according to the amount of erosion of the sea and the consequent stripping off of the overlying æolian rocks. As has been stated, the base rock is often absent. The marked difference in compactness between it and the æolian beds above, has permitted the development of extensive cliffs, with the foot resting on the base or beach rock. Where this base rests well above the sea level, the base rock projects in the form of rugged points and slopes, while where its contact is near the line of wave attack, the soft overlying rocks, undermined at the contact, are maintained in the form of overhanging cliffs. Hence the difference in rock texture is often brought out into striking relief in the topography of the shore line.

While it seems evident that the base rock must everywhere underlie the æolian beds, positive proof of this is absent. This admits of either one of two interpretations:—first, that the dense lower rock is local, and has no special significance, as some of the previous observers have thought, or second, that the surface of the beach rock is irregular, because of erosion before the blown sand was made to cover it. Other observations described below prove the latter to be the correct interpretation.

At various places along the south shore, but notably on the northern side of Devon bay, the surface of the base rock is seen to be distinctly that of an eroded rock surface. Whether the denudation which produced this irregularity is that of land or sea is not apparent; but the absence of a soil at the top, and the presence of pebbly beach deposits over the surface, shows that in some places the waves were at least the last to work.

More convincing evidence of a distinct unconformity and erosion surface is present in the form of a conglomerate beach accumulation resting upon the base rock and covered by the wind-blown sand (Figs. 1-5). In origin this beach is much later than the base rock; for in it are found many pebbles wrested by the waves from the underlying strata, (Figs. 4 and 5), and these are as hard and dense as the parent rock itself. Hence before the pebbles were removed by the waves the base rock had reached approximately its present state of consolidation. The pebble beach here mentioned, also contains numerous shells of species that are now living, (Fig. 3). This unconformity, with all the features here described, may be seen with especial clearness at the point which forms the northern side of Devon bay on Main island.

Accumulation of the Æolian Beds. In the basal portion of the æolian beds on the south shore there is usually a layer of yellowish and reddish coral (or shell) sand, whose color shows the extent of disintegration before covered by the upper beds.* In places this lower discolored layer is absent; but at Devon bay, the typical locality here described, it rests upon the pebbly beach beds and hence indicates a certain period of disintegration before the sand which forms the hills began to encroach.

This proves an elevation between the period of beach formation and the accumulation of the æolian beds: for a soil discolored by disintegration, and containing numerous land shells exists upon a pebble beach containing sea shells. How great this elevation was, cannot be exactly stated; but it was certainly not less than fifteen feet, for at this hight the sand hills rest on the pebble beach. It is *probable* that the uplift was sufficient to connect the various islands, and raise most of the surrounding shoals above the sea. An uplift of fifty or sixty feet would elevate almost the entire area above the present sea level. The reason for stating this supposed greater elevation as a *probability* is, that there is evidence (stated below) that at one time during the history of the accumulation of the blown sand hills, the islands did actually attain this elevation. The uncertainty lies merely in the question whether this higher elevation came at first or later in the history.

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*The red and yellow stain is that of concentrated iron salts derived from the carbonate of lime during exposure to the weather. This color is present in the residual soils of the Bermudas, and is also found frequently among the æolian layers, wherever the accumulation of the sand was checked long enough to allow disintegration to produce this effect.

The time occupied in the upbuiding of the present Bermuda hills could not have been long. It is all contained within the Recent period, for the lowest layers of the dunes rest upon a beach rock containing Recent shells. For a mass of hills so high to be raised by wind action, considerable time is certainly required, because the grains of sand must first have been formed by animals, then prepared by the waves before being built into the islands by wind action. But these processes would be aided by the recent elevation, for this would bring within reach of the waves material that had formerly been scattered on the ocean floor. Moreover such elevation would furnish a smooth coast line of low level, along which extensive beaches could easily be built. Under such conditions of recent elevation as have been here suggested, dune formation must have been rapid, as it certainly was very effective.

It is a notable fact that the high hills and the most continuous land of the Bermudas exist on the southern side of the great area of shoals. Numerous shallows and some rocks occur in the other portions of the reef, but the prominent sand hills are all on the southern side. This is probably due to the fact that the prevailing strong winds are from the south. Hence, here the waves furnished more materials, which they were also better able to grind up; and the winds were also more powerful in the work of driving the beach sand upon the land. No doubt, lower dunes, less numerous and more scattered, were accumulated on the northern side, having since been destroyed, partly by submergence of the land, and partly by wave action. That this is so, is shown by the remains of wind blown deposits now present in the shallows and rocks of the northern side of the reef. That these lower hills could easily be planed down by erosion, will be apparent to any one who has seen the activity of wave action upon a soft limestone rock exposed to the heavy surf of the mid-ocean.

Recent Subsidence. It has been argued that the present irregular form of the Bermuda islands is the result of the corrosive action of the land water, aided by wave attack, the

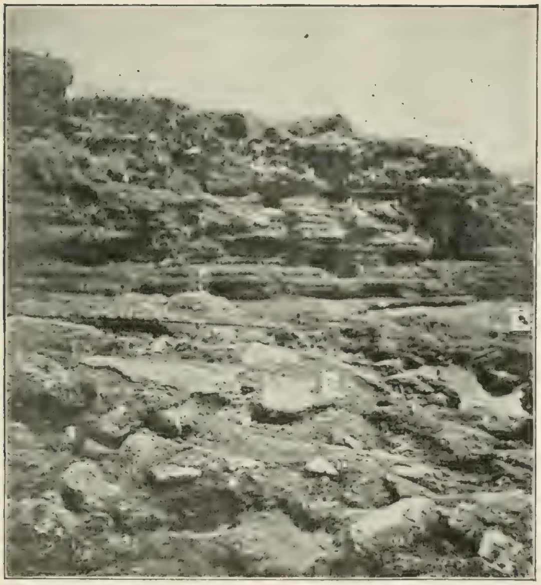

FIG. 5.—PEBBLES OF BASE ROCK (C) IN BEACH ROCK (B).

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chief advocate of this being Dr. Fewkes.* It is true that in places there has been much destruction of the land by wave action, and it is also true that the porous rocks are easily hollowed by the action of underground water; but there are such strong objections to this explanation, and so little in its support, that it seems hardly tenable even as a theory. This phase of the Bermuda problem has been fully discussed by others, and I shall simply state the evidence that appeared to me to prove beyond dispute that the irregular outline of the Bermudas is the direct result of subsidence of an irregular land.

First among these evidences I should offer the very outline and topography of the islands as proof of submergence. It is as typical an instance of a partly drowned land as can be found. The dune hills are in places partly surrounded by salt water, in others entirely encompassed by it, and in some cases entirely submerged. Between the submerged reefs and the sand hills there is every gradation. There is every intermediate stage from a land valley standing nearly at sea level, to a valley exactly the same in general features, excepting that salt marshes exist in the lowest part, and then to valleys occupied by salt water in such a way as to partly or entirely cut off portions of a ridge, forming either peninsulas or islands. An examination of the map shows this gradation, but a visit to the islands, and an examination of their topography, is so thoroughly convincing of subsidence that it seems difficult to believe that the evidence can be questioned.

Another feature of the topography that appealed to me was the abruptness of the coast on the southern shore. There are few beaches, the main part of the coast line being wave-cut cliffs. Had the reef stood at this level long enough to have permitted the carving of the islands into their present irregular shape, the wave action would have built beaches in greater abundance. If the land is hilly, a sinking coast, or one recently lowered, will present a series of cliffs, at the base of which beach deposits cannot accumulate, because the material furnished to the sea coast has not been sufficient to build beaches on the bottom which is sinking, or has recently sunk.

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*Proc. Boston Soc. Nat. Hist., xxiii, 1884-1888, 518-522. Am. Geol., v, 1890, 88-100.

Another feature of the topography pointing toward subsidence, and not denudation, is the disproportionate irregularity of the southern and northern coasts. If the irregularity is the result of sinking, this feature would be expected; for the northern side was originally lower, and hence, by submergence, was more easily separated into islands and peninsulas than the higher, more uniform southern side; but if the outline has resulted from erosion, the high, exposed, southern side should be the part in which the greatest irregularity should be found.

It happens that there is other evidence which will perhaps be more convincing to those who do not believe in the interpretation of geological history from topographic features. As has been stated, peat beds and cedar trees, covered by accumulations of blown sand, have been found at depths between forty and fifty feet below sea level. Besides this, there are numerous caves whose bottoms are below sea level, and in some of these stalagmites occur beneath the salt water. This is mentioned by several who have visited the islands, and may be seen at present in a number of the caves. Even granting that the caverns were carved out by water operating below sea level, it cannot be conceived that the stalagmites were formed while the land stood at its present level. They, at least, must have been formed when it was possible for water to drip from the cave roof to the floor, above the reach of the tide water. Subsidence therefore has occurred, and this to an amount equal to forty or fifty feet, and possibly, though not probably, to a greater depth. This amount of subsidence will account for all the irregularities of outline, excepting the minor features caused by later wave action.

Summary. The history of the Bermudas revealed by the rocks, as I interpret it, is as follows: There was at first (so far as the record shows) a base rock formed by the waves, which ground up shell fragments upon the beach. This shell sand beach was then consolidated into a dense limestone, eroded, probably in the air, and finally attacked by the waves at an elevation certainly at one time about fifteen feet above the present sea level. Hence, first formed beneath the waves, this rock was then elevated and denuded,* and finally depressed and attacked by the waves.

In the last stage it was partly covered by beach deposits of pebbles and shells, which were accumulated during a period so recent that the fossils contained are the same as those now living in the neighboring sea. Then came an uplift, during which land shells lived on the beach deposits; but these were soon covered by blown sand, and through this action of sand accumulation, the outline of the Bermuda hills was perfected by the agency of the winds. This, however, was done at an elevation which at one time was certainly as great as forty or fifty feet above the present sea level.

The last stage has been a depression, causing much land to disappear and the outline of the area to become very irregular. This has carried the level down nearly to that of the beach which was formed before the uplift occurred, and before the dunes were built. There is nothing to indicate that these fluctuations of level were ever very great, but everything suggests rather slight changes. The fact that beaches are now being built, wave cut cliffs rising out of the water, and sea caves being excavated, is indication that the land is now standing at about the present level with little if any change.

Most of the work of construction of the Bermuda islands has been done in recent times. This certainly applies to the dune deposits, which are now consolidated into rock, for they rest upon a beach containing shells of now living specimens. The base rock, however, is much older, there is a marked unconformity between it and the overlying beds. It was accumulated and consolidated into dense rock, and then considerably denuded before the sand dunes began to grow. This makes the history of the Bermudas somewhat more complex than has usually been supposed, and perhaps carries their history back into Pleistocene or even into Tertiary time.

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*It is noteworthy that the peat beds of Ireland island rest on the irregular surface of the base rock at a level 45 or 50 feet below the sea level. This indicates at least the amount of elevation before the sand dunes began.

PHYSIOGRAPIC GEOLOGY OF THE PUGET SOUND BASIN.

By JAMES P. KIMBALL, New York.

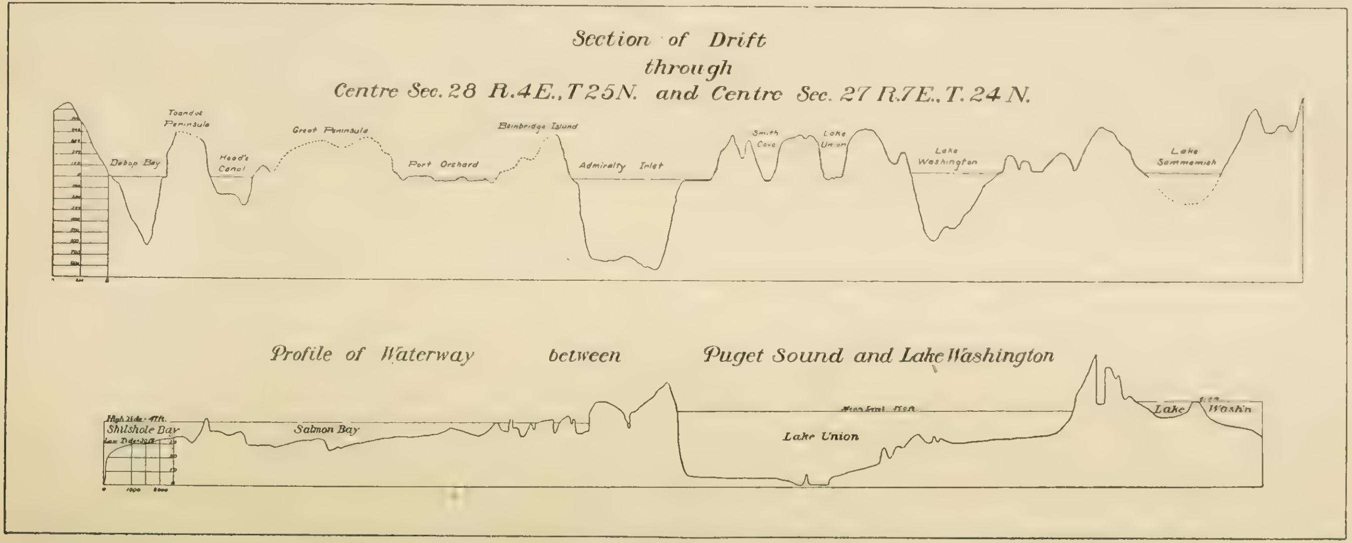
(Plate XIX.)

(*Continued from page 237.*)

The physiographic history of the Puget sound basin, broadly considered, from early Cretaceous well into Pleistocene time, is more than ordinarily incidental to oscillations of level. For the Cretaceous part of that interval the excessive alternations of the Puget coal series bear witness to this fact.

The several occurrences of this series in western Washington may collectively be described as relics of an extensive development of carbonaceous strata which have been involved in the overwhelming vulcanism of the region, referable to different epochs of the Tertiary period. Subaerial denudation following close upon disruption, and eventually succeeded by a sweeping glacial erosion, has cleared the surface of all but isolated remnants. These have escaped destruction through defensive environment of masses of eruptives of subsequent age, and also to some extent through corrugation and profound local depression. Taken as a whole, and regarded as originally a more or less continuous series, it is represented by different fragmental sections, mostly monoclinal, in individual areas. Known exceptions to the prevailing monoclinal structure are the Wilkeson-Burnett-Pittsburg folds and the elevated Sugar Loaf basin. The McKay "basin," as at first described, has proved no exception to the rule. The diverse physical and chemical characters possessed by the coals and lignites in separate developments have obviously been more or less determined by relations to eruptives, and as usual by relative degree of flexure.

Almost every coal seam of each local section examined by the writer, is to a remarkable extent, an alternation of carbonaceous, with more or less sedimentary, material. Exceptions to this mode of occurrence in favor of particular developments are rare. Close and systematic comparisons of disconnected sections remain to be instituted for purposes of correlation. Such inquiries are not without difficulty owing to a general absence of persistent divisional members, like limestones, ironstones and conglomerates, so useful for orientation. The physical constitution of the whole series, where-



PROFILE and SECTION—PUGET SOUND.

ever exposed, is, however, characteristic of an extremely unstable surface throughout the period of deposition. Conditions favorable to vegetable growth obviously unequally alternated with subsidence and sedimentation.

Absence of proof or even indication of particular synchronous denudation areas within the outer limits of the several survivals of the coal series is not without important significance. That the Olympic range was an island and the Cascade belt a peninsula in their relation to the coal-forming area, as sometimes assumed, the weight of present evidence tends to disprove.*

Important facts, on the other hand, go to show that neither the Vancouver range, of which, as considered by Dr. G. M. Dawson, the Olympics are the continuation, nor the Coast range of British Columbia was re-elevated until at the close of the Cretaceous period, nor, indeed, to a considerable altitude until a late Pliocene epoch. Since that event partial subsidence of both ranges has taken place. Though perhaps first outlined at the close of the Triassic period, the Vancouver range occupies an area which during the Cretaceous was, partially at least, one of subsidence and sedimentation, thus constituting a portion of the coal-forming Cretaceous littoral so-called. as recognized north of Puget sound.

"The molluscan fauna" of the Puget group, as illustrated in the Newberry collection from the coal developments of Cedar and Green rivers, and Flett's creek, "being unique in character and composed of types which give little or no definite indication as to geological age, is," says Dr. White, "comparatively worthless as an aid in correlating the Puget group with any other formation."† Yet on the assumed facies of this collection rests the further assumption, not only of uniform estuarine conditions during the accumulation of the coal-bearing series, but also the distinction as commonly drawn between the developments of western Washington and those of the gulf of Georgia. The only characteristic fossil found by Dr. White in the Newberry collection, namely *Baculites chicoensis*, is common to the lower Snoqualmie river and certain islands of the San Juan archipelago—partially submerged reliefs of the Vancouver range in the gulf of Georgia, thus serving, on the other hand, to connect the productive coal series of the Puget group with the Chico beds of eastern Vancouver (Nanaimo group).*

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*Compare Bull. U. S. G. S., No. 51, p. 55; No. 83, p. 107, with Trans. Roy. Soc. Can., VIII, pp. 10, 21.

†Bull. U. S. G. S.. No. 51, p. 56.

On the shore of Bellingham bay, gulf of Georgia, and vicinity, north of the latitude of Puget sound proper, coal-bearing strata in moderate elevation come down to the water's edge. The contact of this formation with the older rocks of the Vancouver series of the San Juan islands, is concealed beneath the bay. Along with a section of some 3,000 feet of lignitic strata still farther to the north at the mouth of the Fraser river, this formation has commonly been referred to the Neocene, on the evidence of earlier determinations of leaf impressions in the Gibbs collection. Both sections, however, though the more recently included by Dr. Dawson with the Puget group of White, equivalent with the Laramie, are apparently so included on the assumption of uniformly a higher range of that group as compared with the Chico horizon or Nanaimo group of Vancouver island, and also of estuarine or brackish water origin.† This assumption not unnaturally follows from the fact that the small development of marine Tejon strata at South Seattle, as hitherto recognized, has been comprised by Dr. White in the Puget group, which on physical grounds has been supposed to occupy transitional relations between the Cretaceous and Eocene formations. The independence and inferential unconformity, together with an extensive areal distribution of these important strata, which really constitute, so far as revealed, the basal structure of the present maritime basin of the sound, has been pointed out in the preceding pages.

Between the Roslyn survival of the coal series at a maximum elevation of some 5,000 feet, and the nearest coal field on the opposite side of the Cascades, namely, that of Green and Cedar rivers, intervenes an Alpine belt about 36 miles in breadth. In common with the similar survival near Wenatchee, at an elevation of some 2,000 feet, this culminating development, according to Mr. Bailey Willis, is undistinguishable from the Puget group.*

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*Diller, Bull. Geol. Soc. Am., IV, p. 217.

†Amer. Jour. Sci., 1890, XXXIX, p. 180.

Isolated survivals of the coal series at considerable altitudes in the western foot hills of Mt. Rainer continue at intervals from the coal field of Green and Cedar rivers as far south at least as the head waters of the Cowlitz, with more or less intimate environment of eruptives, the same as in the Cascade foot hills to the north, and with maintenance of the general quality of coal as distinguished at Wilkeson. These survivals constitute an elevated belt, according to Mr. Willis, from one to six miles in breadth, separated by a much higher eruptive range from the very extensive tract of lignite-bearing strata naturally exposed along the lower waters of the Nisqually and Cowlitz, and also in the upper waters of the Chehalis, well up in the southern foot hills of the Olympics. The occurrence of lignite on the opposite slope of the same range has already been mentioned, but on neither slope have any steps been taken to precisely define its distribution. The carbonaceous products in elevated localities, especially in the neighborhood of intrusive rocks, are of the more bituminous types of lignite, even approaching in places semi-bituminous and anthracitic products. In the less disrupted and less folded parts of the series toward the sound axis, and within its southerly prolongation, the products are comparatively unaltered, or essentially brown coals of indifferent type. No differentiation of such gently undulating parts of the series from the Puget group, as distinguished farther to the north, has yet been recognized. South of the Chehalis only such shallow members of the carbonaceous sandstone series as have been penetrated by moderate river erosion have yet been brought to light, so that little has been revealed as to its sectional range.

Whatever the taxonomic relations of the carbonaceous formation at the mouth of the Fraser, no substantial grounds are apparent for widely distinguishing apart the general horizon of the coal series of Bellingham bay, where it was first made known to geologists, and of the Puget Sound basin, and its prolonged axis toward the south as far as the basin of the lower Columbia. On the contrary, it appears that a single series, occupying the low or axial part of the former basin rises in disrupted form in the foot hills of Mt. Rainer and the Cascades, and also of the Olympics. The present hydrography of the same basin and adjoining area has doubtless been determined by oscillations of level and deformation. Nor, in the absence of paleontological evidence in Washington for comparative purposes, is it indeed easy to discover physical grounds for correlating separately any of the Cretaceous remnants thus distributed from the survivals of the Nanaimo group of Vancouver island, from the study of whose several survivals on that island and in the strait of Georgia has been gathered much knowledge of the Cretaceous littoral north of Puget sound, and its faunal relations. That practically a continuous Cretaceous littoral extended from the strait of Georgia to the valley of the lower Columbia, and laterally across the present expanse of the Cascades and a part of the Olympics, seems at present the most logical explanation of the areal distribution of coal-bearing strata as hitherto recognized within these limits. Apart from the fact of the development of such strata west of the latitude of the sound beyond that hydrographic basin, the persistent thickness of the most westerly survival of the mountain series in the Puget Sound basin proper, as at Renton, serves to denote a much more remote western or expiring edge of the original series.

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* *Vid.* Geol. Railway Guide 1890, p. 265. Correlation of coal-bearing strata in the basin of the upper Columbia with the Neocene, as by Mr. Russell (1893) is stated to rest on evidence of leaf impressions. This remark, it is presumed, refers to early determinations of impressions found in certain collections already mentioned from the sound basin. Bull. U. S. G. S., 1893, p. 20.

Disruption of the coal-bearing series, together with the basal structure on which it was deposited, and its extravasation by eruptives near well-known centres of maximum regional elevation, were doubtless incidental to successive earth movements in the course of which were reared the several coast ranges of Washington and British Columbia. Such movements from the end of the Cretaceous cannot have been brought to a marked suspension till at a period subsequent to deposition of the latest Tertiary carbonaceous strata on the north shore of the strait of Fuca, and again, as far as known, at the mouth of the Fraser, nor indeed to a close, as I shall proceed to show, till well up to the recent period. The limitation of the local Tejon sandstone series, so far as yet ascertained, to the Puget Sound basin, seems, along with other facts already mentioned, to imply a neighboring area of denudation, corresponding to the regional post-Cretaceous elevation in which the Cascades were at first outlined, and the Olympics re-elevated, in common with the Vancouver range and the Coast range of British Columbia.[*]

Orogenic subsidence, giving origin to the Puget sound maritime basin, appears to have been incidental to the same extensive movements on the Pacific border, as shown by the great thickness of the Tejon series at Restoration point. This series was finally uplifted and turned on edge during a later Tertiary epoch, and extravasated with eruptive material which likewise overflowed the less tilted, partly eroded and deformed coal series at Renton. Base-leveling erosion was doubtless concurrent with the epoch of maximum glaciation. To evidences of continued post-Glacial oscillations of level in the Puget sound basin, I have already referred.[†] Further reference to movements of the same kind remains to be made. Evidences of generally concurrent oscillations in British Columbia have been pointed out by Dr. Dawson.[‡]

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[*] Dawson *op. cit.* p. 10.

[†] According to Mr. Eugene Ricksecker, a raised beach with whole clam shells and torredo borings in cemented sand is exposed on the east shore of Admiralty inlet, less than a mile north of Admiralty head, some nine feet above tide. on the north side of an ancient channel, the elevation of which has served to cut off Crockett lake from the sound.

An elevated shell bed, about three feet in thickness, is similarly exposed, eight to ten feet above tide, at the head of the sound, in a railway cut at the mouth of the Des Chutes river, Mr. Erastus Brainerd, of the State Land Commission, to whom I owe this information, has sent me several species of shells which have been identified by Mr. R. P. Whitfield as follows: *Saxidomus giganteus* (Deshayes), *Saxidomus arratus* (Gould), *Saxidomus rigidus* (Gould) and *Schizothyzus nuttalli* (Conrad).—Pleistocene forms common to the Pacific coast,—as well as *Tapis rigida* (Gould), the edible clam of Puget sound waters.

Mr. Brainerd is likewise my authority for the occurrence of a raised beach with whole clam and scallop shells, at Dungeness, strait of Fuca, on Dungeness river, one-half mile above its mouth. The measure of elevation as given is about 25 feet. A similar beach has been observed by Mr. Brainerd at Ballard, some eighty feet from the present shore line of Salmon bay and about eight feet above tide, and still another at Fairhaven.

The above occurrences were brought to my notice at the close of my last visit to Puget sound, too late for a personal examination of the several localities.

[‡] *Op. cit.*, p. 54; AM. GEOLOGIST, 1890, p. 153.

Between South Seattle and Chuckanut bay (Bellingham bay) no survivals of rock at the surface occur, so far as I am aware, on the eastern border of the sound. A boring, 500 feet in depth at the city boundary, (Bay View Brewing Co.) a few hundred feet north of Fossil bluff, is wholly in drift. Beyond the Restoration Point uplift of which Fossil bluff is a survival, no solid basal formation has been discovered to the south, even in a deep boring (400 feet) at Delhi, short, that is, of the solid border of the sound basin as traced in the foot hills of Mt. Ranier and in the Chehalis watershed. A few isolated basaltic outcrops above the drift mantle occur, as I am informed by Mr. Whitworth, in Thurston county, south of Olympia near Tumwater and Beaver, and still higher up the Des Chutes river. The accompanying profiles deduced from contours of government charts and maps, already cited, are intended to indicate the immense vertical development of drift both above and below tide, and to convey some idea of the degree of glacial erosion incidental to the evolution of the present tideways.

Two important vertical sections of the drift mantle have been obtained and graphically plotted:—namely, of the "South Sewer Shaft" at Seattle, one mile north of Fossil bluff, furnished by Mr. Thompson, city engineer; the other, also from shafts, sunk on "school section" No. 16, Tacoma, in the course of an investigation conducted by myself for the State of Washington, of contested "mineral applications." The former comprises a section of 270 feet above mean high tide, the latter 370. Neighboring borings in both parts of the sound basin, previously mentioned, serve to add to these closely observed sections gross measurements of further depths of 500 and 400 feet respectively. Generally similar sections are constructively obtained at intervals from land reliefs and marine soundings. The divide between the sound and lake Washington rises to a hight of 450 feet. Thicknesses of drift up to 325 feet are exposed in many bluffs bared by recent landslides, as at Magnolia bluff, Duwamish head, Alki point, etc. Soundings off some of these precipitous shores give depths of upwards of 900 feet. In lake Washington and Hood's canal (inlet) soundings are reported from 600 to 700 feet. The minimum or measurable thickness of the drift terrane above soundings may be taken at some 1,350 feet.

Well exposed sections of the drift, as seen in numerous vertical scarps, often exhibit more than a single mode of structure. Suffice it to notice, at different relative levels, unequal thicknesses of horizontal silts, generally unconformably overlying plunging and lenticular sands and gravels. Laminated silts, over 100 feet thick, are perfectly exhibited in a vertical bluff on Duwamish (Elliott) bay, at West Seattle, and also on the opposite side, in many street cuts at Seattle. Such deposits, some 25 feet in thickness, crown the Puyallup divide in the outskirts of Tacoma, and there constitute the locus of angular erratic blocks up to several tons in weight. Smaller erratics, likewise angular, are also sparingly strewn through the Duwamish bay silts. Both occurrences point to former higher delta levels of glacial rivers—namely, the Puyallup at Tacoma and the Duwamish at Seattle, and to distribution of erratics by bergs.*

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*In sinking at intervals through several hundred feet of the alluvial column at Tacoma, numerous facts were developed which go to show modification of the drift in local circumstances, mainly through the agency of underground circulation of water under conditions of a copious supply, free percolation and a hydrostatic head. I refer in particular to downward filtration of finer detrital material through the coarser, resulting in assortment of miscellaneous detritus into bedded or lenticular gravels, sands and clays, in the order named, usually upon a floor of impervious hardpan. Gravel beds become coarser toward the bottom. One bed observed at drainage level, about 200 feet above tide, graduates into large cobble stones. All such occurrences throughout the region seem to be near the same relative level—that is, never far from immediate water level. The upper gravels are fine and generally more or less cemented by ferric hydrate. Gravels cemented by clay occur only below the water-bearing horizon—no mechanical separation, as above indicated, having taken place under conditions of quiescent saturation, or, as it appears, below the level of emission.

Another interesting effect of the same remarkable local conditions may be mentioned as follows: At the level of the principal water-bearing horizon, about 235 feet above mean low tide, undermining takes place, followed by rapid erosion of ravines, by which the plateau is dissected. Above that level they are ordinarily dry; while below, the accumulated flow has its own cutting power. Three ravines, known as East, Middle, and West gulches, have been sculptured from the drift terrane down to the remarkable depth of 400 feet to tide level, in the short distance of one and one-half miles—their extreme length. Narrow watersheds, such as the intervening belts of plateau, crowned as they are with impervious silts, cannot be the immediate source of the several flows. The supply of water under a hydrostatic head, on the contrary, is obviously referable to hydrographic basins at a considerably higher elevation within the drift sheet, and to sources near its upper edge. The nearest approach of the Puyallup river is less than two miles. Similar ravines are characteristic of the shore of Commencement bay—all the way to Point Defiance.

The continuity and uniformity of the great drift terrane of the Puget sound basin, and especially the absence of anything like local moraines toward axial parts of the basin, tend along with positive evidence to prove that the mass of its material cannot have been accumulated and distributed by glaciers alone, local to the bordering mountains. Proofs of the existence of powerful glaciers are ample throughout the Cascades, as well as of their important though subsidiary part in the physical history of the region. The existing glaciers of Mt. Ranier are obviously survivals of an extensive system of Cascade glaciers of whose morainal material the present basin of the sound was the catchment. Further facts and considerations, however, sustain a belief that, practically independent of the glaciation of the Cascades, and inferentially also of the Olympics, the axial part of the basin has been occupied by a confluent ice-sheet gathered mainly from the northeast.

Tracks have been indicated, particularly by Dr. G. M. Dawson, of a vast development of this description whose névé gathered in the lofty mountain region between the 55th and 59th parallels, and which covered summits of the interior of British Columbia upwards of 7,000 feet in hight. Above the main river valleys and other principal depressions there is abundant evidence to prove that it stood over 6,000 feet with a thickness of 2,000 to 3,000 feet above the higher tracts of that province. To this commanding development of ice has been given the name of Cordilleran glacier. Projections have been traced southeastward as far as the 48th parallel, and southwestward as far as the southern extremity of Vancouver island, where separate the great orographic valleys occupied by the straits of Georgia and Fuca.*

It has also been shown by Dr. Dawson that the deep sculpturing of the Pacific slope of the Coast range of British Columbia has been mainly effected through the agency of local glaciers which occupied the elevated beds of Pliocene rivers at an epoch when that range stood at a much higher altitude than at present. The range, as likewise concluded, presented a barrier to further advance of the Cordilleran glacier toward the sea, except at certain gaps through which the ice mass

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*Dawson *op. cit.* p. 28; Geol. Mag. (1888) V, 347; VI, 350; Amer. Geol. 1890, 153: Willis, Bull., U. S. G. S., No. 40, 1887.

projected into, and filled at one time the orographic valley identified with the strait of Georgia and Queen Charlotte sound. This, as argued, was during the epoch of maximum glaciation as distinguished from an epoch of local glaciation. North of the 51st parallel local glaciers still survive. Still farther to the north many descend to near sea level. Glacial markings at an altitude of 3,000 feet, as observed in the strait of Georgia, afford a minimum measure of thickness of the glacier mass toward its northern development.*

Evidence of an extension of the Cordilleran glacier through the orographic valley of the strait of Fuca seems not to have been collected at considerable elevations by the Canadian geologists for lack of exploration. Such evidence however, is clear at several points on the west shore of Vancouver island which I have visited. At the head of the fiorded inlet of Barclay sound drift is found at an elevation of at least 1,150 feet on the slope of Broughton peak, together with ice-smoothed surfaces, and again at moderate elevation at Sooke harbor.

Nor has search been made for evidence of a southern projection of the Cordilleran glacier into the orographic valley of Puget sound. The general absence of elevated surfaces of rock throughout that depressed area, precludes glacial markings except upon baseleveled surfaces which are uniformly concealed beneath drift. At Whatcom (Sehome) on Bellingham bay, within the only section on the path of such a projection where occasional rocky surfaces are naturally exposed, north and south grooving up to 90 feet in length, was reported by R. Brown, in the year 1870.†

The old Talbot colliery was opened (1878) just below a mantle of cemented drift on an eroded slanting edge of No. 3 coal seam, which immediately passed under cover of sandstone. When stripped, a glacial surface of the sandstone was disclosed with scratches, as described by Mr. Whitworth, coursing northwest by north (mag.). In the present place reference may again be made to the exceptional tabular surfaces of the Tejon series under thin covering of sand, a few feet above tide, at Alki and Restoration points, and point

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* Geol. Sur. Can. 1886, B. 99.

† Amer. Jour. Sc., 1870, 323.

Glover. Though these surfaces, as above described, are raised Pleistocene beaches which have been swept by tides, they present the only promising field yet recognized for a search for glacial grooving in depressed parts of the Puget Sound valley, and perhaps the only likelihood that some evidences of the kind may still be preserved at points beyond all question of erosive or frictional effects from local glaciers.

It was assumed by the late Prof. Newberry (1884) that glaciation of the strait of Fuca was by way of egress of a great glacier advancing toward the sea from Puget sound and filling that basin.* An obvious objection to such a theory arises from the lack of evidence of the development of an Alpine tract at the head, or to the south, of the latter orographic depression during the glacial period, even before base-leveling or at any previous epoch of denudation. Contrary evidence of a positive character may be drawn from the fact of gentle dips of the superficial carbonaceous sandstone series south of the Chehalis divide. Only after recession of an ice mass from the strait of Fuca, the excavation of which was largely glacial, as shown by the fiorded coast of Vancouver island, could the hydrographic drainage of Puget sound axis have been effected through the present strait except as a sub-glacial torrent like that which flows from the Muir glacier at the head of Glacier bay. Long after the retreat of a sound glacier, an ice dam may have been maintained in the strait of Fuca, in connection with British Columbia survivals of the Cordilleran glacier.

If, on the other hand, a confluence of local glaciers with a projection of the strait-of-Georgia, or Cordilleran, glacier took possession of the orographic valley now occupied by the sound, or even of a similar valley corresponding to the strait of Fuca before that present outlet was deepened by erosion; or, again, at a later stage previous to recession of a dominant ice-mass, it seems natural to suppose that the united waters from all sources, of which the sound area was the catchment, must have found egress toward the south, necessarily at a relative higher stage of elevation of that immediate area, previous to base-leveling of its fundamental structure. To such a stage of superior elevation certain circumstances point, some of which, incidental to a number of oscillations of level, will presently be indicated.

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*Proc. N. Y. Acad. Sci., III, 1884, p. 265.

Into the interesting field of inquiry suggested by the preceding remarks, it will be impracticable to enter far for want of close observation of the drift phenomena in the Chehalis watershed, and still farther to the south. The present low elevation of this watershed is indicated by altitudes of culminating points as follows: Tenino 302.5 feet, Roy, 338, Elma, 92. The parting of the sound and Chehalis (Grey's harbor) waters may be delineated on the map by a single stroke of the pencil. Whether the latter river and harbor may not have afforded such an outlet—follows as a natural inquiry from the suggestive topography of the watershed as graphically exhibited by certain unpublished surveys of the Northern Pacific Railway Co., as well as from well recognized drift phenomena not inconsistent with the development of a terminal moraine coincident with the summit of the same watershed.

The kame-like gravel mounds near Tenino rise from a field of horizontal silts. Other lacustral, prairie-like surfaces in the same region are still characterized by retreated lakes.

A lignite-bearing sandstone formation in low and gentle undulations comes to the surface in the Chehalis valley, constituting the solid border of the sound, as previously designated. An interesting feature of this formation is its widespread alteration for a depth of several feet, beneath a thin cover of soil, into a non-silicated aluminous magnetite.*

To whatever degree the post-Cretaceous movement was elevatory in the border region of the sound, it doubtless ended in resultant relative depression of the sound axis. Throughout the entire succession of alternations of level from that movement all perturbations of the surface down to the final partial re-elevation appear to have taken place unequally, the resultant of later oscillations having been to maintain the Puget catchment at a lower level than the strait of Fuca. This is still indicated by soundings. It is true that material eroded from the upper portion of the drift mass in the Puget basin by river action, and from the shores of the sound by action of the waves, has naturally found its way to the outer channel, there however partially to lodge under the retarding and precipitating action of the strongest of ocean tides, not without marked effect on present soundings. Unequal depression in the way indicated may be regarded as sufficient in itself to afford explanation of the original confinement of sub-glacial drift within the Puget catchment independent of other causes as above suggested. Strong tides having taken possession of the sound, so again at the present day suspended material sluiced in by glacial and other powerful torrents is locally precipitated near their discharge. Even in seasons of violent and abrasive floods like those witnessed by the writer in the month of June, 1894, clear water remains a characteristic of the sound except off mouths of rivers. Circumstances of both kinds here referred to combine to promote silting up of the sound, and the formation of tide flats and deltas.

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*This occurs in the form of solid exfoliations of prismatic or cleavage blocks of the sandstone with the hard and dense ferriferous product up to several inches in thickness. The interior of such weathered blocks is hollow and partially occupied with bleached siliceous residues in the form of sand. In more advanced stages of alteration and decay the ferriferous product takes the form of magnetic sands. Washed into the streams, these finally collect on the shores of Grey's harbor and adjacent ocean beaches where they have long been known as considerable accumulations, concentrated by the tides. The analysis of solid crusts from pits near Elma, is as follows: Iron. 47.70; silica, (free) 6.39; alumina, 23.84; moisture, 4.22 (C. E. Bogardus).

Whether the original configuration of the basal structure of the sound basin was primarily or in a secondary way essentially due to orogenic depression, or, on the other hand, to primary glacial excoriation and deformation, there can be no question but the deep tideways of that basin are substantially due to post-glacial fluvial dissection of the drift filling by existing rivers, as first pointed out by Dr. Newberry.*

Without differentiation from the fiorded type of rock-bound coast between the 49th and 50th parallels northwestward to Bering strait, the inlet of Puget sound regarded as a whole has recently been erroneously instanced by Shaler "as one of the greatest and most characteristic fields of fiord topography on the coast of North America." Except perhaps in point of resultant partial submergence, the physiography of that basin and border, as shown in the present paper, presents the widest difference from that of a fiorded or ice-carved coast.†

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*An. N. Y. Acad. Sci., III, 1884, 265; Dawson, *op. cit.*, (1890) 51.

†Thirteenth Ann. Rep. U. S. Geol. Survey, 1893, II, 203.

The longer axis of the sound, which is also the axis of the great drift terrane, conforms to the natural confluence of powerful streams which have wrought their beds to tide level. Such streams are the Skagit, Skykomish, Stilaguamish, Snohomish, Duwamish (uniting the waters of lakes Samamish and Washington with those of Cedar and White rivers), the Puyallup, Nisqually and Skokomish. As compared with the gentle gradients of the lower parts of these streams, much higher gradients at the close of the glacial period may safely be assumed. These of course were in some measure of the elevation of the drift terrane. Regional elevation or post-glacial re-elevation, of which local evidence has been adduced, has likewise tended to augmented gradients. All gradients have eventually become distributed with the advance of fluvial erosion. Below points of confluence of lateral rivers still deeper excoriation has been effected by flow of the united waters toward the strait of Fuca. Thus were profoundly sculptured great confluent river channels, first, in measure of the elevation of the drift, and afterwards in increased measure of regional elevation. Again, subsidence far below the sea level succeeded by only partial re-elevation has finally served to keep open to the sea all but the more easterly or border channels, and to produce the present system of united inlets together known as Puget sound. Wherever considerable streams unite with the sound, bays have been washing out ever since the principal post-Glacial subsidence, and estuaries, primary and secondary deltas, and tide-flats forming under the precipitating action of a heavy tide.

The more easterly extinct channels referred to are lake Samamish and the river of the same name (also known as the Slough), connecting with lake Washington. These waters constitute a single hydrographic system, the lower developments of which have obviously been cut off from the sound by regional elevation subsequent to fluvial erosion of these connected channels.

At a certain stage of level in the course of the later series of oscillations, the lower channel corresponding to lake Washington, doubtless opened into lake Union, and thence into the present estuary of Salmon bay. The ancient waterways are plainly indicated in the present topography. A minimum elevation of 25 feet, as measured at the portage between the two lakes, has served to divert the whole discharge of the system along with the Cedar into the Duwamish. Evidence has been brought forward to show a general participation in such a recent elevation of all parts of the sound area which I have had an opportunity to study. The road bed of the northern division of the Seattle, Lake Shore and Eastern Railroad, occupies a succession of drained lake basins, all of which were excavated from the drift mass.

In order to take advantage of the slight differences of level between the upper and the lower parts of these fresh-water basins and tide water, a ship canal has been projected by the government to connect them with Puget sound,—namely, 2,600 feet long, and 26 feet deep, through the portage between lakes Union and Washington, with a lock lift of 7½ feet.*

The elevation of the several lakes above extreme low water in Puget sound is reported as follows: lake Union, 25.5 feet, (depth 60 feet); lake Washington, 33 feet, (depth 600 feet); lake Samamish 41.2 feet. The usual level of lake Union is 7.8 feet higher than extreme high tide in its outlet (Salmon bay).

It is unnecessary to instance the great number of examples, both on the Pacific and Atlantic coasts, of harbor formation at the mouths of rivers by subsidence of shore land—often to great depths, incidental to oscillations of level during the Glacial and post-Glacial epochs. The most important havens on the Atlantic coast from New York to the Rio Grande owe their existence primarily to fluvial erosion, and in the higher latitudes in a secondary way to submergence, often followed by partial re-elevation.†

According to Davidson, as cited by Dana, the sub-marine river channels of California indicate submergence to depths of 2,400 and 3,100 feet.* The sub-marine mouth of the Sacramento river, according to Mr. Lawson, descends to a depth of 378 feet,—thus forming the harbor of San Francisco.†

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* Report of Bd. of Engineers, etc., Ex. Doc. No. 40, 52d Cong. 1st Ses.

Alternative routes coincident in alignment from lake Washington to Salmon bay have been surveyed—one connecting with the sound from the head of that bay, and thence through the estuary of Smith's cover; the other through the mouth of the bay. The two estuaries named are separated by a narrow divide, 25 feet above tide, a hight corresponding, it will be noticed, to the uniform measure of regional elevation as above indicated on both sides of the sound. (Ex. Doc., p. 6.)

† Shaler, Thirteenth An. Rep., U. S. G. S., pp. 109, 111.

While those features of the Puget sound basin which, with subsequent modifications, have adapted it to the present hydrographic system were sculptured by agencies potentially incidental to a post-Glacial elevation, the varied topography of the border region has been produced in a subsidiary way incidental to still more recent changes of level. Of these the first was a post-fluvial subsidence below sea level, whence development of marine inlets from river channels. The partial and final re-elevation which followed is indicated by raised beaches and partially base-leveled headlands. Again, while existing and pre-existing lakes within the drift or catchment area, owe their existence in common with the sound itself primarily to specific fluvial erosion, their present condition and relations are incidental to the same more recent changes of level. Thus lake basins have been partially or wholly emptied and tideways branching from the sound either drained or cut off, and so converted into fresh-water reservoirs or drainage channels.

Throughout the broad expanse of drift filling the Puget sound basin, the present work of erosion and deformation, especially along the shores of the sound, is mainly by undercutting, thus giving rise to vertical bluffs. Both sound and river bluffs, however, as well as high shores of lakes, existing and extinct, have been greatly modified by landslides. The extensive development of clay seams throughout the alluvial column, and their interception by water-bearing divisions, below as well as above tide, combine to produce far greater diversity of the surface than can be traced to ordinary effects of sub-aerial erosion. Much of the superficial topography and terrace-like configuration indicated upon the Seattle sheet is due to landslides. Well-known engineering difficulties from the same cause, in this region, as well as recent landslides of sound bluffs on the line of the Great Northern railway, near point Edmonds, might be instanced for purposes of illustration, as also the submerged forest of lake Samamish. Memorable occurrences of the same nature, within recent years, were the great landslides of sound bluffs at Duwamish head, West Seattle, (Sept. 1894), by which several acres were lost to that village; and still more recently the disastrous slide which took place below tide, in the night of Dec. 6, 1894, on the water front of the city of Tacoma.

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*Dana, Manual, 1895, 949.

† Lawson *op. cit.*, p. 271.

The average breadth of the drift mass of the Puget sound basin as above described, may be taken at about fifty miles. Tongues of drift project eastward into glacial valleys beyond the general limit. South Prairie is not far from the centre of a marked projection of this kind. Eroded channels are filled with drift at Wilkeson (1600 feet), where it stands 300 feet above the basal formation. Its occurrence at an elevation of 2,000 feet near Natchez pass has been noted by Willis.

It is, of course, impracticable to determine the derivation of material going to make up the drift mass to the point of discrimination between sub-glacial accumulations from a great glacier occupying the axial part of the sound basin, and re-distribution of morainal material from local lateral glaciers referable to another epoch of the Glacial period.

As I am informed by Rev. Myron Ells, the well-known ethnologist, of Union City, Mason Co., Wash., tusks with connecting jaws and a tooth, probably of an *Elephas*, were obtained by him several years ago at a depth of some 50 feet, in a bluff, 90 feet in hight, at port William near point Dungeness, from a gravel bed interposed between heavy strata of clay. Other specimens were recovered from the same bluff at a depth of 82 feet. These are still in the collector's possession. Bones previously discovered were placed in the Smithsonian Institution.* By the same authority it is stated that nearly a complete skeleton from the drift of Whidbey island was sent to Washington.† Point-no-point is also mentioned as another locality where have been found bones of the same order of mammals.

The rocky islands of the San Juan archipelago to the north of Puget sound, together with neighboring islands in the strait of Georgia, on both sides of that group, and also numer-

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*The Clallam Indian name for the locality, *Stsaiim*, according to Mr. Ells, signifies *bones*.

†Tusks 2½ feet by 6 inches, were found by Mr. G. O. Lovejoy (July 1, 1895), on the north side of Penn's cove.

ous islands on the east shore of Vancouver island, are, as already noted, easily recognized as moderate outlying reliefs of the Vancouver range in a state of partial submergence. So, too, the bordering islands of British Columbia, like the headlands of the main land, are related to the Coast range of that province as lower summits of the same range. In common with the subordinate topography of all the coast ranges of Washington and British Columbia, profound sculpturing of this insular and indented margin is ascribed primarily to fluvial erosion, followed by glacial erosion. Partial submergence distinguishes it in particular from the prevailing physiographic conditions of these ranges. The same fact also distinguishes the coast north of the strait of Fuca from that to the south. The Olympics and the Coast range of Oregon, on the other hand, present gradual slopes to the ocean, their distinguishing features being incidental to emergence.

The Vancouver range which has been only partly explored, is principally made up of crystalline rocks of eruptive type, but believed by the Canadian geologists to represent highly altered sediments of Mesozoic age, the corrugation and primary elevation of which are referred to a post-Triassic event, succeeded by deformation and reduction, if not by subsidence partial or complete.* The probability of participation in the post-Cretaceous elevation of all the coast ranges named, and also in the further Pliocene movements of the Pacific border has also been indicated by the same geologists. Bosses and isolated masses of metamorphic limestone occur on Orcas and San Juan islands. More extensive formations occur as belts on Vancouver, Redonda and Texada islands, in close relation to granitic extrusions—evidently continuous, in the case of the two smaller islands, with the great granite development of the Coast range, as the lowest summits of which these islands have been referred to above. Local replacements of the limestone with magnetite on a large scale are remarkable occurrences, including certain well-known developments on Texada island, hitherto classified by geologists with mineral veins.† In the spring of 1894, having had occasion to study interesting developments of the kind as well as others on Vancouver and Redonda islands, I hope to take occasion to describe them as further striking illustrations of this mode of genesis of magnetite.* Associated with the same secondary developments also occur concentrations of magnetite in workable quantities within compass of basic eruptives, due to weathering action, the locus of such products being determined, among other favorable circumstances, essentially by contact with limestone.

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* Dawson *op. cit.* 1890. p. 6; An. Rep. Geol. Surv., Can. 1886—B, p. 15.

† An. Rep. Geol. Survey for 1896—B. 36.

[Paleontological Notes from Buchtel College, No. 14.]

A NEW DINICHTHYS—DINICHTHYS KEPLERI.

By E. W. Claypole, Akron, O.

(Plate XX.)

The new species of Dinichthys figured in the accompanying plate was found by Dr. W. Kepler, now of Clyde, O., and is in his possession. It is one of the largest and most massive forms yet known, equalling in size *D. hertzeri* of the Huron or *D. terrelli* of the Cleveland shale. Unfortunately the specimen is broken through near the middle and only the posterior portion is available for description. Well aware of the interesting nature of the fossil and knowing the special value of the anterior portion Dr. Kepler with praiseworthy diligence employed two men for three days in digging and searching near the spot in the hope of recovering the lost piece but in vain. The fracture is along the line of a natural joint and very probably the two sides had parted company when they were loosened from the cliff by the undermining action of the stream. This is the usual agent of exposure and of course one piece of a slab may be brought down by a flood while its remaining portion may remain in the cliff for years, and the chance of their ever coming together again in the cabinet of a geologist is infinitesimally small. Quite sufficient however of the fossil remains to establish its distinctness.

It was found in the Cleveland shale of the Rocky river valley and is remarkable for its striking resemblance to the original specimen of the genus *Dinichthys hertzeri*, discovered so many years ago in the Huron shale at Delaware, O., by Dr.

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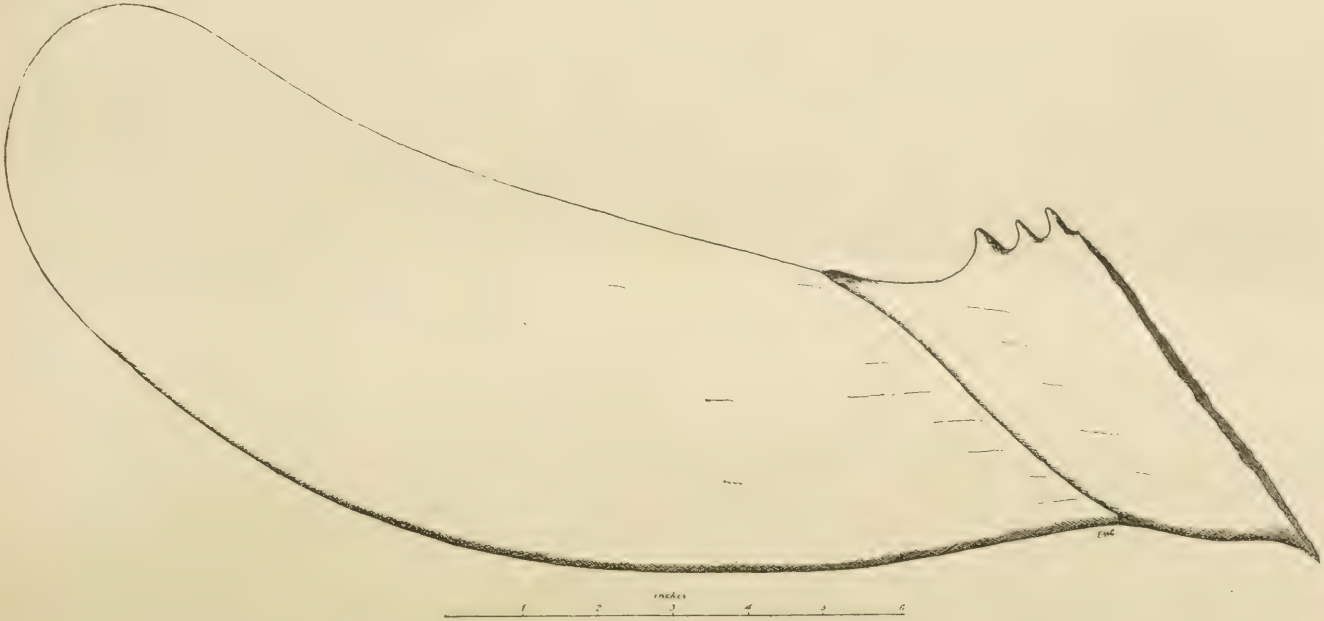
*Vid. (J. P. Kimball) Am. Jour. Sc. XLII, 1791, p. 231; AMER. GEOL. VIII, 1891, p. 351.



DINICHTHYS KEPLERI.

A NEW DINICHTHYS.

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H. Hertzer of Columbus. The characters which have thus far distinguished this latter species from all others are its large size and its serrate mandible. *D. terrelli* of the upper or Cleveland shale—which was suppossed by Dr. Newberry to belong to the same species until its dentition or rather its lack of dentition was proved by Prof. A. A. Wright from a mandible which he discovered on the lake shore at Sheffield, in Huron county (Pal. of Ohio, vol. 1, p. 322)—is distinguished by a sharp cutting edge on the mandible without teeth or denticles.

Every other species yet known in the Cleveland shale is barred from comparison by its small size, except possibly *Dinichthys clarki* of which only a single premaxillary tooth has yet been found and this is so different in form from the type that only provisionally can it be included in the genus. Leaving this probability aside Dr. Kepler's specimen stands alone and is of especial interest as proving the survival of the older type to the higher horizon through the barren interval of the Erie shale.

The teeth on the upper edge of the mandible are therefore one of the chief points in the essential character of the species. But another may be found in the sudden downward curve of the lower edge of the mandible itself just in front of the place where in all species of the genus the bone is suddenly reinforced by an external layer which begins between the dentary and spatular portions on the upper edge and sweeping down carries the lower edge with it and so strengthens the forepart of the jaw. In other species this line curves and runs forward rising again into the great mandibular tooth in front. But here it curves in the opposite direction indicating an extraordinary depth of the mandible toward the front and probably great power in the teeth.

Only three of the teeth remain, but they are of very large size, all measuring half an inch in hight and the foremost of the three reaching nine-sixteenths of an inch.

The mandible is unusually massive. At the fracture and in front of the teeth it is half an inch thick and rapidly increases until for some distance near the middle it measures seventeen-sixteenths which dimension is maintained almost to its lower edge. A crack which exists across the specimen near its middle shows that the mandible at that point is about seven-sixteenths of an inch in thickness.

Other important features will probably be revealed when later finds shall have shown us the complete mandible. Following however the plan previously adopted of relying mainly on this member for the distinction of the species no error can be made in the recognition of this as a new one which I have pleasure in naming after its discoverer.

ON THE GENESIS OF CLAY STONES.

By H. W. Nichols, Chicago.

The appearance and mode of occurrence of clay stones are too well known to geologists to require attention here. It is all but universally agreed that they are formed by the segregation through solution in and re-deposition from circulating ground waters of particles of calcium carbonate originally thinly disseminated throughout the clay matrix in which they occur. The clay stones are simply portions of the clay firmly cemented by crystals of the segregated calcium carbonate. Owing to the compact texture of the clay, the crystallizing forces are so hampered that large crystals (such as occur at Fontainbleu in porous sandstone) cannot form and the concretion shapes itself solely in accord with the amount of material brought to it from different directions.

The clays in which these concretions occur are sedimentary deposits which have formed in quiet waters. While some of the contained lime may be, and frequently is, comminuted lime rock or vein calcite washed in with the clays, other parts are in the form of the small molluscan and protozoon shells which often flourish under such conditions to such an extent as to change what would otherwise be a clay to a marl. Such life existed even in the icy waters in which the glacial clays of the Champlain epoch were deposited.

The glacial clays, besides the powdered lime rock and calcite and the shells which have grown in the muddy waters of the growing clay deposit, may contain as well the crushed or powdered fragments of such land and water shells as the glacier met with. In addition the glacial clay may contain in the form of rock flour many lime-bearing minerals, the basic feldspars for instance, and in this fine state of division it is well known that such minerals decompose rapidly if other conditions are favorable.*

To recapitulate, a recently formed clay bed may have as a source of lime for concretions: 1, comminuted lime and calcite; 2, shells *in situ*, and in the case of glacial clays; 3, comminuted land and water shells, and 4, mineral flour containing lime ready to be liberated as carbonate under favorable conditions.

This carbonate of lime is distributed through beds of clay. Such clay beds are never homogeneous. There are incipient partings parallel to the bedding and thin layers of coarser material as well as contraction joints and faults, all of which afford a comparatively easy passage to water, while the body of the clay is almost impervious, allowing only an extremely slow seepage. In addition there may exist planes of tension where the cohesion of the clay is weakened, and along these the waters may circulate with comparative freedom.

During the progress of segregation of the concretions, the beds are saturated with ground waters. These ground waters charged with carbonic acid and perhaps with other solvent agents, take up and carry in solution portions of the carbonate of lime they meet, and it is through the action of these waters that the concretions are formed.

This much is generally understood, but except for an important paper by Julien upon the humus acids,† to be referred to later, but little has been written upon the *modus operandi* of the formation of concretions, and what has been published refers to the chemical changes by which the material of the concretion is formed rather than to the formation of the object itself.

Dana has suggested in the last edition of his Manual‡ that clay stones are formed by deposition of the lime contained in waters by their evaporation during a drying season. It is evident that the waters circulating in a bed of clay may undergo constant changes in volume, rapidity of movement, degree of concentration and perhaps even in temperature and amount of contained carbonic acid or other solvent. If waters subject to such changes saturate a bed of clay containing disseminated particles of calcium carbonate, there will be periods of solution and deposition of calcium carbonate corresponding to the changes in the character of the solvent waters.

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*Rogers, Am. J. Sci., Series II, vol. 5, pp. 401-5.

†Julien: On the Geological Action of the Humus Acids, Proc. Am. Assoc. XXVIII, 1879, p. 311.

‡Dana: Manual of Geology, 4th ed., p. 139.

It is, however, difficult to see why this should cause the segregation into concretions of the previously scattered particles, for it is to be expected that deposition of material would take place upon the separate particles in the same ratio as solution, so that their relative sizes would be preserved even though each increase or diminish in weight. At first thought it may seem that some particles may be more favorably situated than others, but here also those most favorably situated to receive material during periods of deposition will be most favorably situated to lose material during periods of solution.

If alternate solution and deposition by the solvent waters were alone sufficient to cause segregation and the formation of concretions, then the calcium carbonate in all calcareous clays and shales should be in the form of concretions. There is, however, an abundance of occurrences of calcareous clay and shale where the calcite yet remains disseminated. There are other conditions necessary for the formation of concretions.

With the exception of the limonite balls which require separate consideration, all concretions of common occurrence are crystalline.*

Consequently *clay stones are to be regarded as crystalline aggregates whose growth has been modified by the large amount of foreign matter (clay) present, and the conditions of their formation are the same as those which would in more favorable positions lead to the formation of an aggregate of calcite crystals of the more usual form.*

Therefore the modern theories of saturated solutions should be applied to the problem in the way that the chemists have already applied it to the growth of crystals. There are two conditions which in the light of these theories appear favorable to the formation of concretions. These are:

(1) *The presence of arragonite with the disseminated calcite of the clay beds*; (2) *the presence of the unstable humus acids.*

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*Flint, although amorphous in appearance, is in reality partially cryptocrystalline.

Possibly the presence of finely divided lime-bearing minerals, the basic feldspars for example, in the rock flour of glacial clays may also provide some of the lime.

Shells, such as are found in the clays, contain their calcium carbonate in two forms, as arragonite and calcite.*

As arragonite is more soluble than calcite,† it follows from the properties of saturated solutions that the arragonite must disappear and its material be deposited as calcite upon any already existing calcite particles.

The principles upon which this change depends are well and clearly expressed by Ostwald‡ as follows:

"The equilibrium between the solution and the solid has its origin in their mutual action, and is therefore dependent upon the nature of both. A definite solution pressure may be ascribed to every solid with respect to any given liquid at a given temperature. Solution will go on until the opposing pressure becomes equal to the solution pressure. Consequently tha solubility of a chemical compound is determined only when it is stated what definite solid is referred to."

§"The phenomena of supersaturated solutions are now comprehensible. If a salt solution is allowed to cool or evaporate there is, in general, no reason for the deposition of a solid. If, however, the osmotic pressure in the solution exceeds the pressure of one of the salts, which may separate, and a particle of this salt is brought into contact with the solution, a rapid separation of the salt results and continues until a state of equilibrium is reached. Such solutions are called supersaturated, but it is clear that the supersaturation is only with respect to a certain definite solid: without this reference, the expression is meaningless."

"From a cold solution of sodium sulphate, there can separate $Na_2SO_4 + 7\ H_2O$ as well as $Na_2SO_4 + 10\ H_2O$. As the former is more soluble than the latter, solutions can be prepared which will crystallize in contact with $Na_2\ SO_4 + 10\ H_2O$, i. e., are supersaturated with respect to this salt, while on the other hand, they can still dissolve small quantities of $Na_2SO_4+7\ H_2O$, i. e., not yet saturated with respect to this substance."

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*Sorby: Quar. Jour. Geol. Soc.. 1879, p. 61; quoted by Geikie: Text Book, p. 78.

†Geikie: Text Book of Geology, p. 78.

‡Outlines of Theoretical Chemistry, p. 149.

§Ibid, p. 151.

The two forms of calcium carbonate, calcite and arragonite, of the clay beds surrounded by the gently moving or quiet ground waters, correspond exactly to the two forms of sodium sulphate in the prepared solution. The more soluble arragonite continuously goes into the solution, thereby over-saturating the solution with respect to calcite, upon the particles of which the calcium carbonate of the solution is deposited. Thus the calcite grows as the arragonite diminishes. If a clay bed were absolutely homogeneous all calcite particles would grow in proportion to their surfaces, but in the beds as we find them, some particles are much more favorably situated than others.

Those particles of calcite which lie in those more permeable parts of the bed which form the water ways of the deposit, receive materials in large quantities from the more rapidly moving waters and grow rapidly, while by far the larger part of the calcite, imbedded in the compact, almost impervious clay, can be reached only by small quantities of the very slowly percolating waters, and can grow but slowly. These waters, however, gradually remove the arragonite from these compact parts of the clay and as the natural course of these waters is towards and into the more permeable places which form the main water ways, the dissolved material is taken there and deposited upon the growing concretions.

The calcite appears to have no power to remove the clay from its place and so crystallizes around the clay particles, thus producing the appearance of a "patch work or fine mosaic" which Gratacap found upon microscopic examination.*

In this case the concretion forms as a consequence of a transformation of arragonite to calcite, a physical change of state in the segregating substance. If the humus acids have as much effect as Julien thinks possible, concretions may also be formed through a change in the solvent. According to the article of Julien referred to, some modifications of that complex group of the products of organic decay known as the humus acids have a strong solvent action upon calcium carbonate while other modifications render it nearly insoluble. When a clay bed is so situated that the percolating waters contain any considerable amount of humus acids, the solution of the lime will proceed with comparative rapidity. Humus-like substances may also be formed in the deposit itself by the slow decomposition of the organic matter in and around the shells themselves. These may provide a strong solvent for carbonate of lime localized where their effect is greatest.

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*Am. Nat., vol. XVIII, p. 890.

Humus acids are very unstable and are constantly undergoing changes in composition. Through such changes, the humus acid losing part of its solvent power, becomes supersaturated with calcium carbonate and ready to deposit it upon any calcite it may come in contact with. How powerful an element this may be in the formation of clay stones depends upon the amount of humus that the ground waters may carry, and upon how far into the deposit these substances may penetrate without decomposition. That their action has been at times great, the iron carbonate concretions of the coal measures formed through their agency give evidence. This action of the humus acids is physically similar to the deposition of vein minerals from ascending solutions which as they cool and reach regions of diminished pressure are able to hold less in solution. It is not probable that any progressive change of temperature of the solvent waters takes place in a space so limited as that of a single clay deposit, while the change in pressure is insignificant.

These principles briefly applied here to the commonest and simplest of concretions, the clay stones, appear to be applicable to all concretions. Although concretions contain somewhat less energy than the disseminated particles from which they are formed, the difference is altogether too slight to have any appreciable influence on their formation and it appears that, in practice, some energy must be applied to cause their growth. This energy comes from a change of state, either physical or chemical, by which either the segregating substance or its solvent is transformed from an unstable condition to one more stable under the conditions to which it is subject.

Field Columbian Museum.

NOMENCLATURE OF THE GALENA AND MAQUOKETA SERIES.

By F. W. Sardeson, Minneapolis, Minn.

The synonymy and classification of the Galena and Maquoketa series and their divisions has already been discussed in the American Geologist,* and I have at this time in view a short supplementary discussion of certain difficulties in nomenclature, which have recently developed, and which would seem to prove that the nomenclature is not yet free from unnecessary confusion. For the present, at least, it may be assumed that uniformity in classification has been nearly established, and I shall therefore limit this discussion to the subject of nomenclature. N. H. Winchell and E. O. Ulrich have, in their recent investigation of the two series† quite independently, arrived at nearly the same classification as that which I adopted in my former paper, and the conclusions of these two able geologists, which will no doubt be widely accepted as authoritative, will, in the main, strengthen my own. But regarding the nomenclature, there not only has been, but there will probably continue to be, a burden of discordant appellations of these geologic formations unless we can obviate the sources from which the discord arises. It is with a view to contributing something towards the establishment of uniformity that this paper is offered.

The difficulty arises chiefly from conflicting correlations of the geologic representatives of this area with those of distant areas, whereby the names of elsewhere distinct formations come to be applied to the same formation here. Again, a duplication of local terms is intruded; or unnecessary translations of one term to another obtains.

Winchell and Ulrich (op. cit.) have adopted by correlation the name Trenton instead of the local term, Galena formation, and have rejected the name Trenton for the next older formation, the Beloit formation; a change that is not entirely objectionable considering the transference alone of the name of Trenton from one formation to another, but the future will be different from the past if some one does not find reason to shift the name once more, and add to the confusion of seven kinds of Trenton that already have been entered on the list of synonymous terms for formations in the Wisconsin, Illinois, Iowa and Minnesota area of Ordovician. C. D. Walcott has correlated in like manner the Galena formation with the Utica slate horizon, and not improbably some will still prefer the name Utica instead of Trenton for the Galena formation. N. H. Winchell has presented in detail his argument in favor of the name Trenton, and the reader is respectfully referred to Winchell's discussion for facts bearing upon the question.*

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*Vol. xviii, p. 356, and vol. xix, p. 21.

†Final Rep. Geol. Sur. Minnesota, vol. iii, pt. 2, Introduction, (1897).

I have some reasons for believing that Winchell and Walcott in their arguments upon this question agree more nearly than at first would appear, and that both may be at the same time near the truth. Walcott must have included in his Galena limestone that which has been heretofore called Galena in Illinois, Wisconsin, and around Dubuque, Iowa. and as I have pointed out in my former paper, the Galena formation thus defined includes not only the Galena but also, at the top, the Triplecia bed which contains chiefly Maquoketa (Hudson) fossils. Walcott probably found his evidence of Utica fauna in fossils that are really from this bed only. Winchell, at the time his discussion was written, did, on the contrary, that which all other geologists had done in Minnesota at that time, viz, considered the Triplecia bed as not Galena. Winchell and Ulrich (*loc. cit.*, p. cxv) still tabulate the *Triplecia ulrichi* W. and S., and the associated fossils that are peculiar to this Triplecia bed or Transition formation, with the Maquoketa (Utica) formation's fauna. They are not clear, however, in the definition of this bed† stratigraphically, though, I think they will concur in placing the Triplecia bed apart from the Galena (Trenton) formation, and in the Maquoketa (Utica). It is not improbable that the argument presented by Walcott and that by Winchell may be harmonized, and no conflicting nomenclature result from it, but evidently so long as the nomenclature of the Trenton (Galena) and Hudson (Maquoketa) series depends upon correlation with distant equivalents, difference of opinion in the minds of geologists will cause repeated shifting of names and confusion in this area. Moreover, difference of opinion cannot be excluded.

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*See American Geologist, vol. xv, p. 33-39. (1895).

†See *loc. cit.*, p. civ, l. 29, *et seq.*

I have thought it preferable to adopt a local classification that can be kept free from such shifting opinion, while at the same time admitting the approximate correlation of each part with certain prior established geologic formations of other areas. Since this provisional classification, if you will, was given to publication, the latest work by Winchell and Ulrich has been published, but very evidently it was in press at the same time as my own (*loc. cit.*) and therefore no attempt to compare the two classifications could have been made by them. The first half of their discussion had been published, in fact, in part I of the volume, and on page l, a table of formations shows nearly their final revised system of designations, the reasons for the position of which are, however, given only in part II, which is just published. To include their classification in my discussion of the Galena and Maquoketa series was not practicable until now, because the argument for its presentation was yet unpublished.

Hudson River or Cincinnati.	*Richmond limestone.*	*Wykoff formation.*	Maquoketa series.
	Utica shale.	*Maquoketa formation.*	
	(*Not Defined.*)	*Transition formation.*	
Trenton.	*Trenton.*	*Galena.*	Galena series.
	Black River.	*Beloit formation.*	
	Stones River.		

Messrs. Winchell and Ulrich have replaced, as far as possible, all original names by others that are derived from correlation. Their paper is one of the most important on the subject that has been written and although I cannot here discuss the merits of their correlation, it will be worth the while to compare their classification with the local classification which I have recently outlined, in order to show the true relation between the original names and those derived by correlation.

The foregoing table will show the relation of the two systems of nomenclature with respect to the correlated divisions, the subdivisions being omitted.

The two columns on the left side of the diagram show the application of Winchell and Ulrich's correlation of the two series and their divisions, while the two columns on the right show the classification that I have adopted, as before described. The smaller divisions are placed in the middle columns of the diagram to facilitate comparison. The name Richmond limestone seems to have no claim to priority over any other term, and it should be rejected in this area at least.

Oscar H. Hershey has recently used the name Pecatonica limestone for that which Winchell and Ulrich call Stones River; a new name the use of which scarcely accords with scientific usage, since that author neither defines the term Pecatonica limestone nor seemed to have any reason for introducing a new name. He was discussing an entirely distinct subject* and so far as I can learn, he had no more occasion to introduce a new name for a part of the Ordovician, than one who is writing on the Ordovician would have to suggest a new name for some part of the Pleistocene. Notice of the name "Pecatonica limestone" is given place here, however, lest the name be sometime resurrected to the confusion of nomenclature.

Another source of confusion in nomenclature is a kind of systematic substitution of allied names, the classification remaining the same. The following quotations will serve to illustrate the argument that is given in support of such changes, and the nature of the change itself. "Really, Dr. Sardeson's name" (Camarella bed) "must be thrown out altogether for the simple reason that, according to the investigations of Winchell and Schuchert, and those recently published by Hall and Clarke, one of his supposed *Camarellas* proves to belong to the new genus *Parastrophia* H. and C., while the other is the type of another new genus and is now called *Cyclospira bisulcata*." Again the words, "The upper member of his Orthisina bed (Clitambonites bed of this book,)"† show

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*Preglacial Erosion Cycles in Northwestern Illinois, AMERICAN GEOLOGIST, vol. XVIII, p. 72.

†See Final Rep. Geol. Sur. Minnesota, Introduction, p. xcix, bottom of page.

Ordovician System.	Maquoketa (Hudson River) series.	*Wykoff formation.* ("*Richmond limestone.*")	14. Orthis bed.
			13. Leptæna bed.
		Maquoketa (*Utica*) *formation.*	12. Orthoceras bed.
			11. Diplograptus bed.
		Transition formation.	10. Triplecia bed.
	Galena (Trenton) series.	*Galena* (*Trenton*) *formation.*	9. Maclurea bed.
			8. Lingulelasma bed.
			7. Camarella bed.
			6. Orthisina bed.
		(*Black River, 4-5.*) *Beloit formation.* ("*Stones River*" *or Birdseye, 1-3.*)	5. Fucoid bed.
			4. Stictopora bed.
			3. Stictoporella bed.
			2. Bellerophon bed.
			1. Buff limestone bed.
	Saint Peter Sandstone (Chazy), 150 feet.		
	Shakopee (Upper Calciferous). 50 feet.		

a similar change. In short, the liberty has been taken to change the names of geologic formations because the fossil after which the names were given, have been placed in a new genus or in new genera. Thus Stictopora bed has become Rhininidictya bed, Orthisina bed has been changed to Clitambonites bed, and it is proposed to reject the name Camarella bed. It would be necessary not to name geologic formations after geologic type fossils if the name of the formation must change as often as the fossil is reclassified. A name once given should not be changed, or at least must not be subject to varying and continued change as such license would necessitate. The chief source of confusion comes, however, from discordant correlation.

Unless uniformity in classification can be maintained throughout a continuous area, in neighboring counties and in adjoining states, there will be little use in attempting exact correlation with distant areas, and thus also, unless uniformity in nomenclature can be locally established the introduction of names from distant correlated formations can be of little use and possibly may be very obstructive. I have therefore proposed both to classify the Ordovician uniformly and exactly over the entire area in the manner that accords best with the nature of the formations, and, to preserve a system of nomenclature that will be free from confusion of terms due to attempted correlations with other areas. I would indicate the correlated formation by additional names, as Galena (Trenton) formation or Trenton (Galena) formation, as in the accompanying diagram, in which I have combined the local classification for our area, with Winchell and Ulrich's correlation. In such a scheme the nomenclature can be changed by shifting the terms Utica, Trenton, etc., without confusing the classification. Ultimately it may be that the names Galena series and Maquoketa series will be no longer of use; that is, the correlation may become exact instead of approximate. To be sure, authors have applied the name Trenton, etc., as if there were no doubt as to the exact equivalency, but not only have the same authors failed to use the same names in neighboring counties and states consistently, but also even in the same place authors vary in their application of them.

For more than fifty years geologists have attempted to apply the names "Trenton" and "Hudson River," in this area with varying results, and unless better uniformity prevails soon, exact correlation with the Ordovician of New York state may be called a failure, and a local classification and nomenclature must be preserved intact. Further, it may be suggested that no one thing will be a greater aid in establishing the desired correlation with other areas than will a locally exact and uniformly applied system of nomenclature under which to assemble the accumulating evidence.

THE AGE OF THE GREAT LAKES OF NORTH AMERICA.*

A Partial Bibliography, with Notes.

By Alexander N. Winchell.

1863. A. C. Ramsay: "On the Glacial Origin of certain Lakes in Switzerland," etc., Amer. Jour. Sci., Ser. II, vol. xxxv, p. 324; in footnote, p. 342, Ramsay agrees with Sir Wm. Logan in ascribing the great lakes to the action of glaciers.

1871. N. H. Winchell: "The Glacial Features of Green Bay of Lake Michigan, with some observations on a probable former outlet of Lake Superior," Amer. Jour. Sci., Series III, vol. II, p. 15; on p. 19. Winchell assumes the existence of lake Superior in Tertiary times.

1872. Charles Lyell: "Principles of Geology," 11th ed., vol. I, p. 418; Lyell believes in a partial pre-glacial origin for the great lakes. Instance the following words, speaking of lake Superior: "If we are compelled to grant that such inequalities of movement have occurred in post-glacial times, we may well suppose that others of far greater extent contributed, before and during the Glacial period, to form the basin of the great lake itself."

1874. J. S. Newberry: "Surface Geology of Ohio," Report of Geol. Survey of Ohio, Geology, vol. II, p. 72, and other places. Dr. Newberry seems to have hazy ideas on the origin of the great lakes, and, in trying to make definite statements, apparently contradicts himself, as for example, in the following extracts:

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*Read before the Geological Club of the University of Minnesota; meeting, October 17, 1896.

"All our great lakes are probably very ancient, and their formation may have begun during the Coal Measure epoch," p. 72.

"There can be no doubt that the basin of each of the great lakes has been produced by a local glacier," p. 74.

"Lake Superior lies in a synclinal trough, and its mode of formation, therefore, hardly admits of question," p. 72.

1878. E. W. Claypole: "On the Pre-Glacial Geography of the Great Lakes," Canad. Naturalist, New Series, vol. VIII, p. 187; Claypole believes that the great lakes, with the possible exception of Superior, occupied the valley of a pre-glacial river, and (p. 205), "The great American lakes, therefore, are nothing but merely drift-dammed pools," and not essentially eroded by the ice. This view gives to the lakes the same age as the theory of origin by glacial erosion of the basins.

1879. J. D. Dana: Manual of Geology, 3d ed., pp. 394 and 825. The depressions in which the great lakes lie must be geosynclinal, or "Intermont," in origin; thus, the lakes would probably have a great age.

1881. J. W. Spencer: "Discovery of the Pre-Glacial Outlet of the Basin of Lake Erie." read before the Amer. Phil. Soc., March 18, 1881. Spencer amplifies the theory that a great river occupied the valley of all the great lakes in pre-glacial time; he presents a map of the river system in lakes Erie and Ontario, and asserts that all the lakes "owe their existence to sub-aërial and fluviatile agencies." See reprint of above article in Reports of Geol. Surv., Pa., vol. Q4, p. 361.

J. W. Spencer: "A Short Study of the Features of the Lower Great Lakes during the Great River Age." Proc. Amer. Assoc. Adv. Sci., vol. XXX, p. 131; another presentation of the above view. Lake Superior in not on the whole excepted, see p. 139.

1882. W. M. Davis: "On the Classification of Lake Basins," Proc. Boston Soc. Nat. Hist., vol, XXI, p. 315; Davis believes in the theory of a pre-glacial river, but thinks lake Superior, at least in part, existed in pre-glacial times.

1886. A. Winchell: "Walks and Talks in the Geological Field," p. 278: "The Niagara river has been at work on a vast gorge ever since the Devonian Age. Probably none of the great lakes except Superior, then existed." Winchell thinks the other lakes were caused by glacial erosion and drift accumulation in a pre-existing river valley.

1888. G. K. Gilbert: "Changes of Level of the Great Lakes." The Forum, June, 1888. See pp. 419, 420, where Gilbert gives a glacial erosion origin to all the great lakes.

J. W. Spencer: "Origin and History of the Great Lakes of North America," Proc. Amer. Assoc. Adv. Sci., vol. XXXI, p. 197.

J. W. Spencer: "The St. Lawrence Basin and the Great Lakes," Canad. Rec. Sci., vol. III, p. 232.

1889. G. F. Wright: "The Ice Age in North America," on page 316 and 317 Wright ascribes the excavation of the basins of all the lakes except the western end of lake Superior to the action of the great ice-sheet.

1890. J. W. Spencer: "Origin of the Great Lakes of America," Quart. Jour. Geol. Soc., vol. XLVI, p. 523.

1891. J. Le Conte: "Elements of Geology," 3d ed., p. 560, The basins of the great lakes "probably did not exist in the Tertiary period but in their place was a great depression draining northeastward."

J. W. Spencer: "Origin of the Basins of the Great Lakes of America," AMER. GEOL., vol. VII, p. 86; Spencer here gives a map of the pre-glacial river system occupying the valley of lakes Michigan, Huron, Erie, and Ontario.

1894. J. W. Spencer: "Deformation of the Lundy Beach and Birth of Lake Erie," Amer. Jour. Sci., Ser. III, vol. XLVII, p. 207.

J. W. Spencer: "A Review of the History of the Great Lakes," AMER. GEOL., vol. XIV, p. 289.

1895. I. C. Russell: "Lakes of North America." P. 29: "While lakes in synclinal basins might be expected to be of common occurrence, they are in reality so rare that so far as I am aware none of the tens of thousands of the lakes of America can be pointed to as examples." Russell probably forgets lake Superior. See also p. 97.

1896. J. W. Spencer: "How the Great Lakes Were Built," App. Pop. Sci. Mon., vol. XLIX, p. 157; This is Spencer's latest and fullest amplification of his theory: "The lake basins are simply fragments of the old valleys of the St. Lawrence river and its tributaries." These fragments were cut off by the crustal oscillations and drift accumulations of the Glacial period.

J. D. Dana: "Manual of Geology," 4th ed., p. 947; Dana seems to have modified his views to agree with those of Claypole, Spencer and others.

J. Le Conte: "Elements of Geology," 4th ed., p. 584.: The opinion expressed in 1891 remains unchanged.

W. Upham: "Origin and Age of the Laurentian Lakes and of Niagara Falls," AMER. GEOL., vol. XVIII, pp. 169-177; Upham sums up the probable truth in the following words: "It seems not improbable that the warping and deformation of the land surface enclosed and changed into land-locked basins some parts of the Tertiary river valleys of the Laurentian lakes area, so that these lakes may have begun to exist in some form before the Ice Age," p. 171.

RELATION OF THE LAFAYETTE OR OZARKIAN UPLIFT OF NORTH AMERICA TO GLACIATION.

By WARREN UPHAM, St. Paul, Minn.

THE LAFAYETTE PERIOD, INCLUDING THE OZARKIAN EPOCH, REFERABLE TO THE QUATERNARY ERA.

On account of the new order of geologic conditions which prevailed in the Lafayette period, namely, extensive deposition of gravel, sand, and loam, on the coastal plain of the southern Atlantic and Gulf states, and, closely succeeding, a great and general uplift, with extensive and deep erosion of the Lafayette and underlying beds, I concur with Hilgard and others in referring the Lafayette period to the early part of the Quaternary era. Before that time, through the long Tertiary era, our eastern part of the continent had long been comparatively undisturbed by epeirogenic movements; but, beginning with the Lafayette period, these movements have been the most notable geologic events during all Quaternary time to the present day, first causing the accumulation of great sheets of snow and ice, and afterward making them melt away.

From their relations to the great Quaternary epeirogenic movements, the epoch of the deposition of the Lafayette formation, and the closely ensuing epoch of great elevation and erosion which Hershey has named the Ozarkian epoch, seem to me better referred, as constituting together the Lafayette period, to the Quaternary than to the closing part of the Tertiary era, in which they are placed by McGee and others. Hershey takes the middle ground of referring the epoch of Lafayette deposition to the end of Tertiary time, and the Ozarkian elevation and erosion to the beginning of the Quaternary era.* To my mind, however, it seems quite certain that the continental disturbance expressed in the Ozarkian epeirogenic uplift was earlier manifested in the deposition of the Lafayette beds. Indeed, these beds appear to me to belong to the initial stage of continental elevation, as deposits of flooded rivers overloaded by the erosion of residuary clays and valley gravel and sand along the upper parts of the stream courses, due to the incipient epeirogenic uplift, but laid down on the coastal plains above the sea level, where the decreased gradients and slower currents of the streams no longer permitted them to carry forward their load. But when the uplift became greater, in the Ozarkian epoch, all the marginal plains shared with the uplands and mountain regions in deep and widely extended erosion.

Ozarkian Elevation, in its Culmination, the Cause of the Ice Age.

To some glacialists, it has seemed to be a difficulty, if great altitude was the cause of the cold and snowy climate producing the ice-sheet, that the fjords and submerged continuations of river valleys eroded when the northern lands stood much higher than now, but yet had no ice covering. It may be readily answered, however, that the long continuation of the upward movement, before reaching its culmination, allowed the streams to erode the fjords to depths 1,000 to 3,000 feet, or more, below the present sea level, while the bottoms of the fjords were so raised as to be land valleys; and that later the elevation reached its maximum and was continued so long that the slow accumulation of snow from year to year formed ice-sheets hundreds and even thousands of feet thick, enveloping the north half of North America and northwestern Europe. The ice surface over Sweden, and over the Laurentide highlands of Canada and the basins of lakes Superior and Winnipeg, was probably one to two miles higher than the land, equaling or exceeding the Greenland ice-sheet, which rises in its central part 8,000 to 10,000 feet above the sea.

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*Am. Naturalist, vol. xxxi, pp. 104-114, Feb. 1897. Compare the Am. Geologist, vol. xvii, p. 389, June, 1896.

NATURE AND SOURCE OF EPEIROGENIC MOVEMENTS.

LeConte, in his recent presidential address before the Geological Society of America, expresses the opinion that "no adequate cause has been assigned and no tenable theory proposed" to account for the widespread epeirogenic movements which have occurred through all the earth's history, but perhaps never on a grander scale than during the latest and present, comparatively short, Quaternary era. It seems to me, however, that these great but slow and long continued crustal movements are a part of the results of the earth's contraction by the gradual and constant cooling of its interior. The crust, being hard and rigid, must adapt itself by deformation to the very slowly diminishing mass of the plastic or molten interior. This is effected, as I believe, between the times of great folding and upheaval of mountain chains, by the moderate distortion of the earth's general form, uplifting parts of the continental areas and depressing other lands or mostly parts of the ocean basins, until the accumulating gravitative stress of the deformed crust, when thus broadly uplifted and elsewhere depressed, shall be sufficient to crumple some belt into a mountain range. Then the elevated or protuberant areas sink to an isostatic condition, with the formation of faults and tilting of large crustal blocks, producing extensive monoclinal mountains, such as are exemplified by the latest movements of the Sierra Nevada and Wasatch mountain belts, and even by the origin of many minor mountain ranges of the Great Basin of the western United States.

This view I first stated in 1889,* and have since given it prominence in numerous papers touching on the causes of the Ice age. Like LeConte, in his address before quoted, I think that "elevation was, at least, one cause, probably the main cause, of the cold and the ice accumulation" during the Glacial period.

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*Wright's Ice Age in North America, appendix, pp. 573-595. Compare Appalachia, vol. VI, 1891, pp. 191-207 (also in the Popular Science Monthly for Sept., 1891).

The foundation principle, that the crustal uplifts are due to the earth's slow cooling and contraction, being indeed its resultant deformation to fit the hard exterior to the plastic contracting interior, was earlier enunciated by Crosby,* from whom I receive this key revealing the much debated causes of the Quaternary ice-sheets.

PERMANENCE OF CONTINENTS AND OCEANIC BASINS.

It is evident, from the foregoing statement of my theory of the source of the earth's energy exhibited in its great epeirogenic oscillations, that these are wholly harmonious with very long geologic duration of the continents and ocean basins, which Dana first clearly saw and taught.

At the same time, however, it seems probable and nearly sure that the crustal uplifts and subsidences, many times repeated during the long geologic ages, in combination with various tracts of especial weakness in the crust, may have led to considerable changes in the boundaries and extent of continental areas, so that some parts of these and of the deep sea may have interchanged their places.

THE CHAMPLAIN DEPRESSION TERMINATING THE ICE AGE.

The general parallelism of the events constituting the Ice age in North America and in Europe implies the synchronism and common cause of the glaciation of both these large continental areas. Further, it implies also a common and synchronous cause of the departure of the ice-sheets, which on each continent was rapid, as shown by the character of the drift deposits, and was attended with the advance of a warm temperate flora and fauna near or even upon the borders of the wasting icefields. The Ozarkian uplift, we may therefore confidently conclude, was at least as extensive as these vast glaciated regions; and it may also quite probably have included the intervening ocean bed. Transitions of the earth's deformation, aided by the immense weight of the ice-sheets, may have produced alternate waxing and waning of glaciation in some districts, and it should probably also be accepted as the explanation of more extended glaciation during some parts of the Quaternary era in the most widely separated quarters of the globe, as, besides North America and Europe, in the Himalayas, New Zealand, and Patagonia.

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*Proc. Boston Society of Natural History, 1883, vol. XXII, pp. 455-460.

For the two greatest glaciated areas, on the opposite sides of the North Atlantic, the Ozarkian uplift was ended by a general subsidence of the ice-burdened lands to levels somewhat lower than now. This time is named the Champlain epoch, from the occurrence of its fossiliferous marine beds, overlying the till, in the basin of lake Champlain. On the borders of the ice-sheets, when the lands thus sank to their present hight or lower, a mild climate returned; with warm summers. The ice was melted fast away, assuming, however, steeper marginal slopes than before, and consequently acting with its maximum vigor in the amassing of marginal moraines whenever any temporary halt or slackening of its retreat was caused by secular changes of the average annual temperature and snowfall.

The grandest monuments of the Ice age, in its moraine hills and ridges formed along the receding front of the continental ice-sheets, therefore belong to the Champlain epoch or closing stage of the Glacial period, when the depression of the land favored the mainly rapid, but at many times wavering or halting, recession of the ice boundaries.

EDITORIAL COMMENT.

NATURAL SCIENCE.

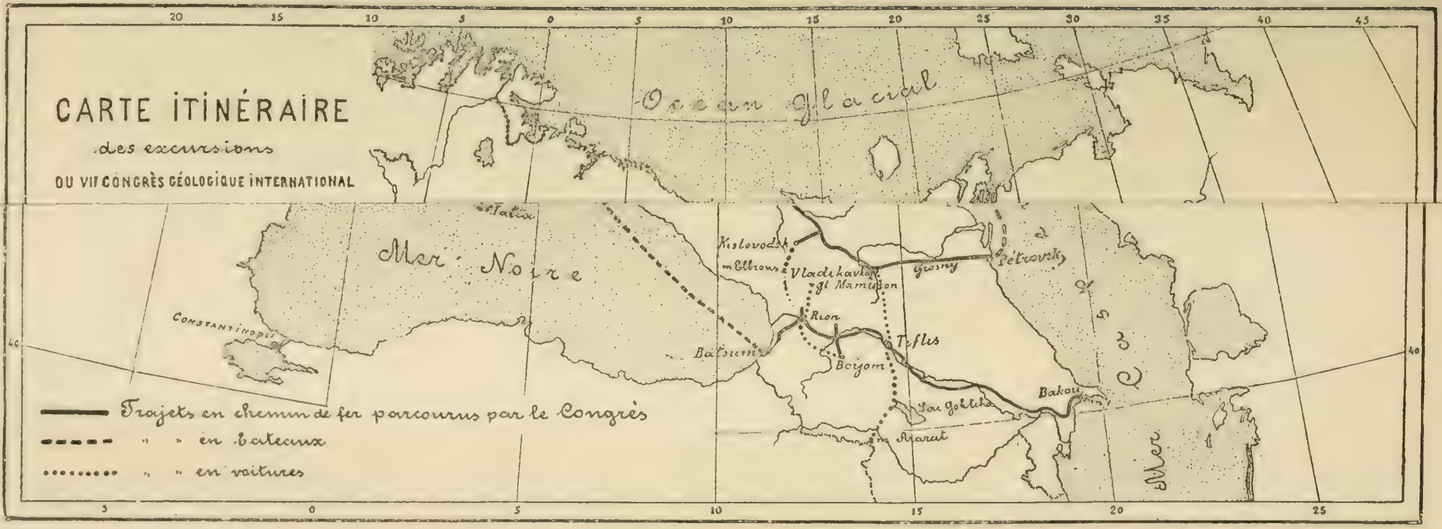
The January number of this vigorous English magazine is unusually interesting and valuable to American scientists. The English scientist is very inquisitive and has learned that in America are many interesting things. He reads American books and tells frequently what he thinks of them. He knows what American scientists are doing. It may be that the English readers of American scientific papers, on any specified topic, are as numerous, and probably as appreciative, as American readers of the same. It is for this reason that English reviews, published in English magazines, are sought for in America and that English magazines are so widely known and read in America. In the January number of *Natural*

Science are sections or paragraphs, or even lengthy reviews, on the following American topics: "The Biology of the Great Lakes," "An Eastern Question," "Revision of North American Slugs," "James Hall," "Botanical Scraps from America," "Cope's Factors of Evolution," "American Ethnology," "Hayden Memorial Prize," "Mexico and the Metric System." Mr. Bather's review of Cope's *Factors of Evolution* is a long and critical synopsis and complete examination of that work. We thank our English cousins for their appreciation of our progress and for their friendly talk. N. H. W.

SEVENTH SESSION OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS.—ST. PETERSBURG.

A translation of the second circular from the Committee on Organization of the International Congress of Geologists to be held in St. Petersburg next summer, was published in the April number of THE GEOLOGIST. This month the map of the excursions is added, together with a supplementary circular which the committee has been obliged to issue because of the unexpectedly large number of applications for cards entitling the holders to participate in the excursions for the small sum which the committee, thanks to the assistance of the imperial government, the municipal authorities of the cities along the routes, and certain large proprietors and companies interested in the development of Russian resources, has been able to fix. This last circular has evidently been issued with regret by the committee, and while it will cause great disappointment to many who would have used the occasion for the benefit of the scientific world, it is of the utmost importance that its purport should be published as widely as possible in order that no one may unadvisedly incur the serious expense and trouble of a voyage to Russia under the misapprehension that he will be allowed to join in the excursions.

The qualification for admission to these excursions which the committee has adopted is an extremely stringent, and it may be thought a very arbitrary one; and is no less than the restriction of the privileges to *those geologists whose published works are known to the committee.* The book recently issued by M. de Margerie professes to be a bibliography of bibliographies, and as such would not be expected to contain the in-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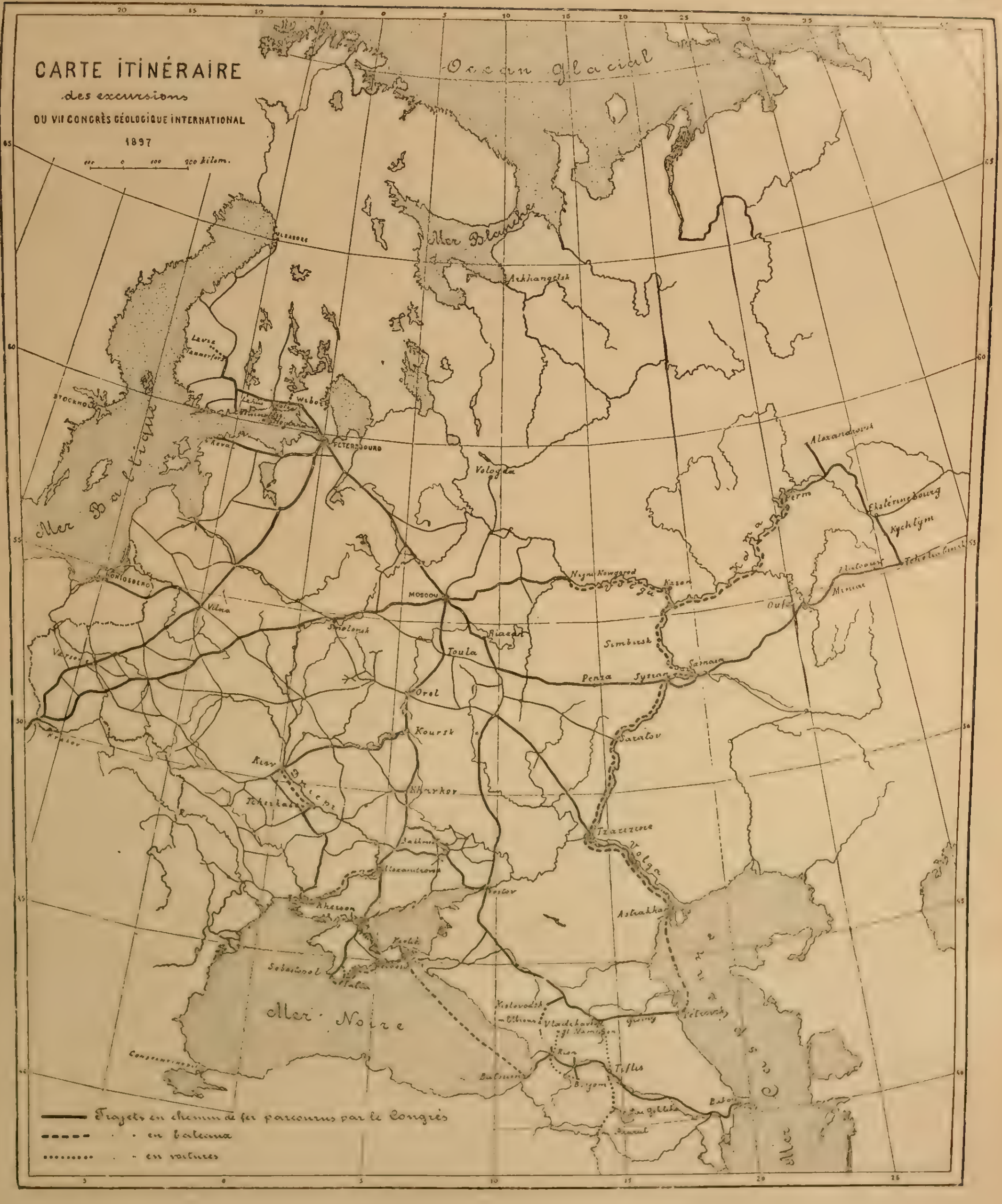
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dividual works of a geologist unless they were of a bibliographical character. Yet there are enough instances where one or two titles not belonging to this category appear, to make one anxious lest this work should be made the standard by which the eligibility of a geologist should be determined. If this "Catalogue of geological bibliographies," recently issued by the Congress committee (of which Serge Nikitin is president and Emm. de Margerie secretary) should be regarded as such standard, the rule would be prohibitory in many cases, in spite of the fact that valuable contributions to geological literature had been made by the parties excluded.

The Russians have long been in Europe the only competitors of the Americans in liberal and large undertakings, and they have determined to outstrip us in the magnitude and generosity with which this the seventh session shall be conducted. They have an enormous terrane, incredible resources, which are but little understood outside of their own official scientists, and they have evidently determined that this gathering of the geologists of the world shall be so directed as to make these facts known throughout the civilized world and mark an epoch in the history of Russia's material progress.

Following is the supplementary circular mentioned.

P. F.

The Committee of Organization of the Seventh International Congress of Geologists, after having done all that depended upon itself for the best organization of the excursions which will take place before and after the session, found itself in the position to propose to geologists to take part in them on the least expensive conditions. The low price of the excursions is due to the fact that the Russian government lending its aid, at the request of the committee, has deigned to grant, as we had the honor of stating in the first circular, all possible facilities as to the sojourn of the geologists in the empire. Now that these privileges have obtained a wide publicity the Committee receives every day requests, both from geologists whose presence at the Congress is very desirable, and from numerous persons unknown, who have not made their names familiar in the domain of geology. Consequently the Committee is obliged to announce that *geologists only have the right to profit by the facilities accorded for their arrival in Russia and their participation in the excursions*, and that these favors are in no way extended to persons who have not made themselves known by geological publications.

This exclusion is due principally to the excessive number of geologists of other countries—more than 600—who have expressed the desire to come to Russia and to take part in the excursions; there is, indeed, every reason to believe that this number will be exceeded. If, in addition, others desirous of traveling in Russia at a minimum expense come to join these, the committee will find it impossible to organize, in a satisfactory manner, the excursions for the geologists for whose exclusive profit the Russian government has made great sacrifices. For these reasons the Committee of Organization finds itself, with regret, obliged to announce that from now on, all those persons who are not known to it by geological works, in case of their having sent the membership fee to the treasurer, may be inscribed as members of the Congress, but can not profit by the advantages accorded, we repeat, to geologists solely.

In the name of the general Committee of Organization.
The Bureau.
A. KARPINSKY, *President*,
TH. TSCHERNYSCHEW, *General Secretary*.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Geology of Minnesota, 1892-1896. Vol. III, Part II, pp. 475-1081 of the Final Report, 4to. Paleontology. By EDWARD O. ULRICH, JOHN M. CLARKE, WILBUR H. SCOFIELD, NEWTON H. WINCHELL; (The Geological and Natural History Survey of Minnesota, N. H. WINCHELL, State Geologist, Issued February, 1897.)

Perhaps at no time in the history of palæontology has there been such rapid changes in its nomenclature and terminology as at present. For nearly fifty years, the classic reports of the veteran palæontologist, James Hall, state geologist of New York, together with the venerable writings of Billings and Salter in Canada, as regards the Lower Silurian palæontology, especially, have proved quite sufficient for all the practical purposes of general geology and stratigraphy. But now that palæozoology or palæobiology are sciences as exacting as their sister sciences, it seems quite necessary to go deeper into the functional relations of the various characters as exhibited by the fossil organic remains and present a classification which can better receive the species created during the past fifty years and render them more intelligible. For example: the genera *Spirifera*, *Strophomena*, *Orthis*, *Murchisonia*, *Metoptoma*, and *Pleurotomaria*, each stood as the head of an exceedingly large army of species which, with as perfect material as the museums of America can now afford, ought to show such characters as would lead to a sub-division of these genera into *sub-genera*, at least, if indeed we cannot say quite positively that the newly constituted sub-generic designation of Hall and Clarke, and Beecher, and Winchell and Schuchert, and Ulrich and others are truly of generic importance.

One fact remains, and that is, that everywhere in the animal kingdom whether in Recent biological studies, or in palæontology, we ought to try and and ascertain the true biologic interpretation of the characters observed, and not rest satisfied until the relations existing between classes and orders and genera are established on a reasonably natural basis. There are no hard and fast lines in the realm of fossil organic remains, no more than in recent biological researches.

We almost go so far as to say that in studying any extensive series of fossil remains, even from the old palæozoic formations, we cannot truly state that either a *genus* and a *species* is a term that can be definitely and distinctly characterised so as to include known or afterwards-to-be discovered forms.

Nevertheless, it is quite convenient and reasonable to create genera and species. A careful study of the palæontologic characters of a group of organisms from a definite series of sediments will be most helpful in future correlations of strata in different parts of the continent, serve to throw light upon the origin and cradle of certain types, and on their subsequent migrations and vicissitudes due to the differences of marine conditions in those early times.

The board of regents of the University of Minnesota and the state geologist and his staff deserve congratulations on the completion of vol. III, part II of their final report upon the geology of Minnesota. Vol. III, pt. I contained, besides a "historical sketch of investigations of the Lower Silurian in the Upper Mississippi Valley," a series of chapters on "Cretaceous fossil plants from Minnesota," by Leo Lesquereux; "The microscopical fauna of the Cretaceous in Minnesota," etc., by Woodward and Thomas; "Notes on other Cretaceous fossils in Minnesota," N. H. Winchell; "Sponges, graptolites and corals from the Lower Silurian in Minnesota," N. H. Winchell and Charles Schuchert; "On Lower Silurian Bryozoa of Minnesota," E. O. Ulrich; "The Lower Silurian Brachiopoda of Minnesota," N. H. Winchell and Charles Schuchert, the whole forming a handsome volume of 474 pages, illustrated by forty-one plates and thirty-four figures, issued July, 1895.

This volume (III, pt. II, issued Feb. 2d, 1897) opens with an introduction by N. H. Winchell and E. O. Ulrich on "The Lower Silurian deposits of the Upper Mississippi Province," giving the stratigraphic and geographic distribution of the fossils. This is followed by a chapter on "The Lower Silurian Lamellibranchiata of Minnesota," by E. O. Ulrich; "The Lower Silurian Ostracoda of Minnesota," by E. O. Ulrich; then comes two chapters by Prof. J. M. Clarke on "The Lower Silurian Trilobites of Minnesota," and on "The Lower Silurian Cephalopoda of Minnesota," closing with Chapter X, on "The Lower Silurian Gastropoda of Minnesota," by E. O. Ulrich and W. H. Scofield.

The editors record with sadness the loss of the last mentioned author who died during the preparation of this volume. His death will not only be a loss to Minnesota, but to geological science.

In reviewing the palæontology of this volume I will deal with each chapter separately. Part II of vol. III, opens with Chapter VI,—"*The Lower Silurian Lamellibranchiata of Minnesota.*" By E. O. Ulrich, pp. 475-628. In this chapter we note that the genus *Ambonychia* Hall, has been amended so as to include *A. bellistirata* Hall, the type *A. amygdalina* Hall, and a new species *A. affinis*, whilst the genera Clionychia (Ulrich), and Byssonychia are made to include the remainder of the known species of the Ambonychiidæ of Minnesota, and for that matter of other portions of North America. One new species each of Clionychia and Byssonychia are described: *C. nitida* and *B. tenuistriata*.

[The genus *Whiteavesia* has been created, p. 513 *et seq.*, for the reception of certain forms of *Modiolopsis* such as *M. cincinnatiensis* Hall and Whitfield; *M. modioliformis* M. and W. To these two forms Ulrich adds another, *Whiteavesia*, *W. subcarinata*].

The genus *Orthodesma* has not been disturbed but certain species "of the same general type as *Modiolopsis* and *Modimorpha*," having from *one* to *three* oblique cardinal teeth in each valve, have found a resting place in the newly-constituted genus *Modiolodon*, with *M. oviformis* Ulrich (sp.) as the type, *M. winchelli*, *M. ganti*, *M. patulus* and *M. ? gibbus*, most of which Ulrich states might have been placed in his own genus *Ischyrodonta*.

Colpomya is a new genus made to receive four forms: *M. constricta*, the type from Kentucky, *M. demissa* (a Minnesota species) and two other species. *Modiolopsis milleri* Ulrich, and *M. faba* Hall are also placed under this general description.

Aristerella nitidula Ulrich, is a newly described form both as to generic and specific name. Ulrich says of this species: "It might have been placed into either *Actinomya* or *Eurymya*, were it not for its unequal valves."

Certain forms previously referred to the broad genus *Modiolopsis* have been referred to *Endodesma*, *E. cunetum* Ulrich, being the type. Six species are referred to this genus. Ulrich doubtfully placed them "near *Rhytimya* Ulrich, an early type of the PHOLADELLIDÆ." *Modiolopsis trentonensis* is also referred to this genus.

Psiloconcha, a genus very closely related to *Modiolopsis* or *Orthodesma* has been created to receive *P. grandis* Ulrich, *P. minnesotensis* and a number of other forms from other states. *Prolobella* is also doubtfully referred to the *Modiolopsidæ*, *P. striatula* Ulrich being made the type, whilst *Avicula trentonensis* and *A. oviformis* of Hall, 1847, are also referred to this new genus.

In the Cyrtodontidæ of Minnesota Ulrich includes: *Cyrtodonta* Billings, *Vanuxemia* Bill., *Matheria* Bill., and his own genus *Whitella*. *Cyrtodonta rugosa* and *C. canadensis*, both of Billings, are taken as the types of this genus. Ulrich adopts *Cyrtodonta* of Billings instead of Conrad's genus *Cypricardites*, and on page 535 gives his reasons in a clear and concise manner. *Cyrtodonta* is used both by Canadian and European authors, and we agree with Mr. Ulrich in his remarks, excepting his last remark regarding the use of the term *Cypricardites* in nomenclature. We think it very unwise to refer any form of fossil organism to a genus which has not positive *status* in the department of palæontology.

Ten new species of *Cyrtodonta* are described from Minnesota, in this volume, besides five others previously recorded by the author from the same state, in the "19th Ann. Rep. Geol. and Nat. Hist. Surv., Minnesota," for 1893. Forms referable to *Vanuxemia* Billings, but oftimes referred to *Cypricardites* by United States writers are also noted. Under *Matheria* Ulrich places one Minnesota species: *M. rugosa* Ulrich, whilst under his genus *Whitella* he places twelve forms at times very difficult to separate.

Under the family NUCULIDÆ, Mr. Ulrich has made an interesting study of the shells referable to the genus *Ctenodonta* Salter. He has arranged the large array of species of this genus into "*six* more or less well-marked groups" in which an attempt is made to classify most of the North American species from the limestones of the Quebec group of Newfoundland, as well as from the Lower Silurian rocks of Tennessee. We should have been pleased to have seen the mist dispelled which hangs over the genera Clidophorus, Cucullela and Nuculites. Without entering upon the task, Mr. Ulrich classes two Lower Silurian species from Minnesota under the first of these three genera, which, as he remarks, may be synonymous. From the NUCULIDÆ Mr. Ulrich has separated a number of species referred to the genus *Lyrodesma* and constitutes the family LYRODESMIDÆ, taking *L. planum* Conrad, as a type of the genus and adding two new species from Minnesota, viz: *L. acuminatum* and *L. cannonense*, besides his *L. major* (*sic*) for *L. majus*. The remaining forms are referred to *Technophorus*, Miller; *Allodesma*, Ulrich (n. gen.); *Rhytimya*, Ulrich; *Cuneamya*, Hall: *Sphenolium*, S. A. Miller, and Saffordia.

Plates XXXV to XLII, inclusive, of this volume. contain no less than 396 figures or illustrations of Lamellibranchiata.

Chapter VII. *The Lower Silurian. Ostracoda of Minnesota.* By E. O. Ulrich. The leading features in this interesting contribution to a humble though important group of fossil organic remains is the "provisional classification of the Palæozoic Ostracoda," which at once gives us a very systematic and comprehensive view of the families and genera of North America, as well as foreign Ostracoda. Many of the recent changes in nomenclature made by Prof. T. Rupert Jones are adopted and a decided step in advance may be said to have been made as regards the study of these abundant little creatures of the old Palæozoic rocks of Minnesota. Such contributions to science by the State of Minnesota are a credit to the State and a help to palæontological enquiries the world over. The following genera are recorded from Minnesota: *Leperditia*, *Leperditella*, *Schmidtella*, *Aparchites*, *Primitiella*, *Primitia*, *Halliella*, *Beyrichia*, *Eurychilina*, *Dicranella*, *Jonesella*, *Bollia*, *Drepanella*, *Dilobella*, *Ctenobolbina*, *Ceratopsis*, *Tetradella*, *Moorea*, *Macronotella*, *Cytherella*, *Bythocypris* and *Kransella*, comprising in all *twenty-four* species and varieties from the Lower Silurian of Minnesota. The four plates accompanying the letterpress contain 230 illustrations of Ostracoda, most of them magnified twenty diameters.

(*To be continued.*)

A Summary of Progress in Petrography in 1896. By W. S. Bayley. (From monthly notes in the *Amer. Naturalist.* Waterville, Me., 1897. Price 50 cents.) These summaries, of which the present is number 15, contain the author's well-known monthly notes arranged in consecutive order and having their original pagings. An index of authors and one of subjects have been added. U. S. G.

Biennial Report of the State Geologist [of Missouri] transmitted by the Bureau of Geology and Mines to the 39th General Assembly. By C. R. Keyes. (Mo. Geol. Survey, 63 pp., 7 pls., 1897.) This report reviews the work of the Missouri Survey, especially for the last two years, gives statements of the results accomplished in various lines and outlines the investigations already in progress or contemplated. The work has been mainly along two lines, subject work and areal work. The first has been given more attention thus far, while the second is well under way. Thus far the printed areal work has been confined to small areas, or sheets, in the mining districts, but one county (Green) report is nearly ready for the printer and in another county the mapping is practically finished.

The work in progress consists of eleven detailed sheets, reports on five of which will appear soon; an extended investigation of the coal deposits, which it is hoped will be ready for publication during the ensuing year; a report on the building and ornamental stones; work on the formations and structure of the Ozark region; summary of the general geology of the state; an investigation of the minerals not mined; and reports on the resources of the different counties.

The publications thus far issued are: (1) four biennial administrative reports; (2) five bulletins,—bulletins are now discontinued; (3) eleven larger volumes, and a twelfth (areal geology) is in press. U. S. G.

RECENT PUBLICATIONS.

I. *Government and State Reports.*

Mo. Geol. Survey, vol. 10, 533 pp., 22 pls., 1896. Physical features of Missouri, C. F. Marbut; Formation of Quaternary deposits, J. E. Todd; Bibliography of Missouri geology, C. R. Keyes.

Mo. Geol. Survey, vol. 11, 632 pp., 39 pls., 1896. Clay deposits, H. A. Wheeler.

Boletin de Instituto Geologico de México, Nums. 4, 5 y 6, 270 pp., plates and map, 1897. Antonio del Castillo (sketch, with portrait), J. G. Aguilera; Prologo, J. G. Aguilera; Estados de Durango, Chihuahua, Sonora y Sinaloa, R. F. Buelna; Itinerarios geologicos, Ezequiel Ordoñez; Itinerarios geologicos, J. G. Aguilera; Sinopsis de geologia Mexicana, J. G. Aguilera; Rocas eruptivas, Ezequiel Ordoñez.

Proc. U. S. Nat. Mus., vol. 18, 1896. Diagnoses of new Tertiary fossils from the southern United States, W. H. Dall; Notes on asbestos and asbestiform minerals, G. P. Merrill; Description of four new Triassic Unios from the staked plains of Texas, C. T. Simpson; Fossil jelly fishes from the Middle Cambrian terrane, C. D. Walcott.

Rept. Minn. Park Com. on the State Park at the Dalles of the St. Croix, 1897. The St. Croix river before, during and after the Ice age, Warren Upham.

Mo. Geol. Survey, 63 pp., 7 pls., 1897. Biennial report of the state geologist transmitted by the Bureau of Geology and Mines to the 39th General Assembly, C. R. Keyes.

II. Proceedings of Scientific Societies.

Proc. Ala. Indust. and Sci. Soc., vol. 6, pt. 2, 1896. Gold milling in Clay Co., Ala., at the Idaho mine, Joshua Franklin; Manganese ores of Georgia, W. M. Brewster.

Jour. of the Western Soc. of Engineers, vol. 2, no. 1, February. Natural distortion of rock in place as shown on the Chicago drainage canal, C. L. Harrison.

Bull. Geol Soc. Amer., vol. 8, pp. 59-86, pls. 3-9, Feb. 17, 1897. Diabase pitchstone and mud enclosures of the Triassic trap of New England, B. K. Emerson.

Ibid., pp. 87-112, pls.10-13, Feb. 13. Sheetflood erosion, W J McGee.

Ibid., pp. 113-126, Feb. 15. Earth-crust movements and their causes, Joseph Le Conte.

Ibid., pp. 127-156, Feb. 17. Stratigraphy and paleontology of the Laramie and related formations in Wyoming, T. W. Stanton and F. H Knowlton.

CORRESPONDENCE.

Observations on the Cimarron Series.—In early April of 1896, I traversed the Cimarron series from southern Kansas across parts of central and western Oklahoma and northwestern Texas, to obtain such new data as I might concerning the extension of the Cimarron series and its members southwestward from the Kansas-Oklahoma area described the month previous in my article, "The Permian System in Kansas." * In the September following, I examined of the western extension of this series in Clark and Meade counties, Kansas, and Beaver county, Oklahoma, certain small areas filling out gaps in my previous work. These two reconnaissances, which covered by rail, wheel, stage and saddle an extensive area, occupied but little more than a month altogether and were less complete than I could have wished, especially in the case of the southern one, but they sufficed to add considerable to the knowledge of the series.

The more important of the new observations, with some related matter, are here presented.

Briefly, most of the subdivisions that I have described in the Cimarron series in Kansas are more or less clearly recognizable in central Oklahoma, and some of them, at least, reach much farther southwestward.

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*Colorado College Studies, vi. pp. 1-48.

To what extent the classification given for the Cimarron rocks in Kansas, needs to be modified for adaptation to the Kansas-Oklahoma area as a whole, will appear in what follows.

THE HARPER BEDS AND THE SALT PLAIN MEASURES.—As surmised in "The Permian System in Kansas," the horizon of the great salt spring at the head of Salt creek, in Blaine county, Oklahoma, belongs to the Salt Plain measures; but the observations made in the April reconnaissance show that the evidences of salinity are not confined to the Salt Plain measures but that the Harper beds are also distinctly saliferous. In the gently inclined plain drained by Salt and Kingfisher creeks, and reaching from the Cimarron river westward to the foot of the bluff-range of the Cave Creek gypsum, the outcrops of the Harper and Salt Plain formations constitute all of the pre-Neocene part of the surface, the Salt Plain beds forming a more westerly and upper zone of unknown width below the Flower-pot body (and Cedar Hills base?) of the bluffs, and the Harper beds occupying a (presumed proportionally large) lower part of the valley and crossing the river to the eastward.

The saline character of the Harper is manifested west of the river and of Dover by the frequent brackish and salt wells encountered. Thus, the difficulty of drawing a line between the Harper and the Salt Plain is increased, and these should perhaps be considered as composing a single saliferous formation, for which, from its being traversed by Kingfisher creek and having the town of Kingfisher within its area, the name of *Kingfisher* would be appropriate. But notwithstanding this difficulty, the Salt Plain measures force themselves upon us as a *very pronounced*, and, if interupted, *persistently recurring saline* horizon. Reduced to subformational rank under Kingfisher, the Salt Plain measures would be, in a sense, its more important, though its thinner member, and genetically would represent the culminating time of conditions which were more or less favorable to the deposition of salt during the entire Kingfisher epoch. The conditions are nearly parallel with those of the column represented by the gypseous Flower-pot shales and the thinner, massively gypsiferous Cave Creek beds above them, the Cave Creek representing the culmination of conditions only imperfectly expressed in the Flower-pot shales, viz., conditions favorable to chemical deposit (precipitation—in this case, of gypsum) as opposed to those favorable to mechanical deposit (sedimentation). This culminating relation of the Cave Creek gypsum formation to the gypsum-sparred shales of the underlying Flower-pot, was one of the considerations that led me to place the former with the latter in the Salt Fork division, rather than alone or in the Kiger division. It will be seen further on that we have in the Dog Creek formation a third circle of precipitation, one of dolomite, and that this too has its preparatory and its culminating stages.

Because, from Kansas southward to the Stony hills of Blaine county, Oklahoma, and to an unknown distance beyond, the line between the Dog Creek and the higher formations is sufficiently well distinguished and the danger of confusing this formation with any other dolomite formation is eliminated by its constant association with the Cave Creek gypsum formation, and finally because (as stated in "The Permian System in Kansas") the red shales of the Dog Creek agree better in lithological character and color with those of the Salt Fork division below the Cave Creek than with those which are most characteristic of the Kiger division, and often contain, in their lowest part, seams of gypsum similar to those in the horizon next below the Medicine Lodge gypsum, (viz., the Flower-pot horizon of the Glass Mountain formation), I am now led to transfer the Dog Creek formation from the Kiger to the Salt Fork division, placing the line between the two divisions where, in preparing my earlier paper above cited, I suspected that it should be drawn, viz., at the summit of the Dog Creek formation. Thus we have in the Salt Fork, or lower division of the Cimarron series, three cycles of precipitation: the first of salt, the second of gypsum, and the third of dolomite, each including two stages, a preparatory and a culminating stage: the preparatory represented in each instance by a *greater*, and the culminating by a *less* thickness of *rock*, but the former stage by *less* and the latter by *greater* bodies of the *precipitate*. This relation may be graphically indicated in the following table, which expresses the

GENETIC RELATIONS OF THE SALT FORK DIVISION.

CULMINATING STAGE	*Chapman*	Dog Creek or Stony Hill cycle of precipitation of Dolomite.
PREPARATORY STAGE	*Amphitheatre*	
CULMINATING STAGE	*Cave Creek*	Ætna cycle of precipitation of Gypsum.
PREPARATORY STAGE	*Glass Mountain*	
CULMINATING STAGE	*Salt Plain*	Kingfisher cycle of precipitation of Salt.
PREPARATORY STAGE	*Harper*	

In this table the Cedar Hills sandstone is omitted as probably of only local development. *Ætna*, from Ætna, Kansas, is here proposed for the first time as a common name for the Glass Mountain and Cave Creek formations, expressing the genetic and chemical relationship between them. The names *Glass Mountain*, *Amphitheatre* and *Chapman* are explained farther on.

The so-called great salt spring at the head of Salt creek is the source of a large amount of strong brine. It is not in the form of a single bold spring, as might be inferred from its name. The divide between the Cimarron and North Canadian rivers, opposite the head of Salt creek, consists of Black-jack-wooded Neocene sands, commonly known as "Jack-sands," whose thicker parts seem to include superficial æolian layers and deeper deposits of aqueous origin with basal, water-bearing gravels. Above the great salt spring, the eastern border of this wooded upland crowns an acclivity of between 300 and 400 feet, the lower 235 of which (including the Glass Mountain and Cave Creek formations) forms precipitous canyon-walls, while the remaining upper portion (the Dog Creek dolomites) forms the less steeply cut walls and uneven floor of a broad, basin-shaped infra-sylvan excavation, or amphitheatre, which I shall call the *Chapman amphitheatre*, after Mr. H. C. Chapman. It is the same as the "Natural Bridge park," cited by the writer in a previous article, from Mr. Chapman's letter. Descending from the sandy, wooded rim, the incipient drainage-lines of the amphitheatre converge to a canyon down which descends steeply, from the base of the Cave Creek formation to a level some 160 feet lower, a dry torrent-bed, strewn with blocky boulders of gypsum. At the foot of this lies a moderately inclined, narrow, springy mud-flat, or salt-plain, the head of which is that of permanent flow in Salt creek, and practically marks the summit of the Salt Plain measures. This salt-flat varies from 20 to 50 rods in width, and has a length of between three and four miles. Its upper end is ensconced in the depths of the canyon, the lower part being in the more open country where the great Trans-Oklahoman or *Marcy** bluff-range breaks down to the peneplain of the Cimarron river. From this flat arises and through it flows the brine-stream, which, beginning as a mere rill at the upper end of the incline, and joined in its course by other rills and rill-formed branches, soon attains the proportions of a large brook. The latter maintains its character as a pure brine-stream till it reaches the mouth of Bitter creek, by which it is rendered too impure for use in salt-making, as the water brought into it by Bitter creek is highly charged with gypsum.

At the time of my visit to this locality, to which I was conducted by the kindness of Mr. H. C. Chapman, salt was being manufactured by five different parties who had taken up claims along the borders of the brine-stream. This salt is manufactured very cheaply, as the brine, according to members of the White family, who were the largest manufacturers, is so strong that it makes from one-third to one-half of its bulk of salt, and fuel is cheaply obtained from the Black-jack woods that clothe the Jack-sands on the neighboring hights, a little cedar also (now nearly exhausted) being cut and rolled down the bluff for fuel at the Saunders salt works, which are in the deepest part of the canyon and nearest the head of the stream. The salt was being hauled by by wagon to Kingfisher and El Reno and sold there, it was said, at a price so low as to compel a reduction in the former price of the Kansas salt sold in those markets.†

Owing to the crudeness of the method of manufacture now employed at Salt creek, the salt there produced contains a trace of red clay sediment, or of ferric oxide derived therefrom, imparting to it a faint reddish tinge. This, however, could be easily overcome, and there is no reason why the finest grades should not be made there. With the brine strong and pure, no pumping necessary, and fuel cheap and abundant, the natural conditions for the cheap manufacture of salt are there apparently more favorable than at any other western point east of the Rocky mountains.

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*After Captain R. B. Marcy, who (? first) more or less discriminatingly studied it, and called attention to it by description and mapping in his Red River report.

†Wholesale at $6 per ton; retailed at 50 cents per sack of 100 pounds.

In my paper on "The Permian system in Kansas," I have referred to outcrops of the Salt Plain measures as far northeast as Little Salt creek, north of Hazelton, Kansas, and to its having been pierced as a rock-salt-bearing formation in a boring at Pratt, still farther northeastward, in the Cimmaron-Arkansas divide. It apparently gives rise to the group of brine-springs at which salt is being manufactured in a primitive way by claim-holders on Elm creek in western Greer county, Oklahoma,* and to the salt water which has given name to the Salt fork of Red river. Its extension much farther southwestward seems probable, though I have not yet determined its position in the Permian section of northwestern Texas given by Mr. W. F. Cummins in the second annual report of the Texas State Geological Survey. Occurrences described by Mr. Cummins in that report (pp. 446 and 447) are so similar to those of the Salt Plain formation that I shall be surprised if future exploration does not show some of them to belong to it. On the other hand, it is practically certain that some of the saline outcrops of the Texas Permian belong to a lower horizon.

THE GLASS MOUNTAIN FORMATION.—The Cedar Hills sandstone of my Kansas Permian section has not been satisfactorily identified in central Oklahoma, and it is doubtful whether it is possible to distinguish there the lower or theoretically Cedar Hills, part of the beds between the Salt Plain and the Cave Creek, from the lower part of the Flower-pot shales, which, however in Oklahoma as in Kansas differ somewhat from their more specialized upper part. It therefore seems necessary to regard all of the beds above the Salt Plain and below the Cave Creek as one formation. This may be called the *Glass Mountain formation*. The name refers to the Glass mountains,† whose own name has been taken from the slabs of selenite (popularly called "isinglass) which there and at intervals elsewhere are strewn upon the outcrops of the more characteristic upper portion of the formation (the Flower-pot shales), rendering them conspicuous even at great distances by their glistening and sparkling appearance. A thickness of about 160 feet (unrepeated barometric measurement) was obtained for the Glass Mountain formation at the great salt spring of Salt creek, where the base and summit of the formation are respectively marked by the summit of the Salt Plain saline floor at the head of the spring and by the base of the Medicine Lodge gypsum bed.

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*For a knowledge of these springs and other facts of geological interest, I am indebted to Mr. S. T. Sayre. He describes three large springs on the south side of Elm creek where salt is being made. One of these, he says, is about six miles east of the west line of Greer county, and the others about half a mile and a mile below the first. At spring No. 1, two parties were making salt when he last visited the place, and at each of the other two springs one party. He reports the brine as being very strong, at the upper spring at least, forming a thick crust.

†Called also the "Gloss mountains," the form being sometimes used in the singular. The name is spelled "Glass" on Interior Department maps of the territory and on Roessler's map of Texas and Indian Territory (1874), and "Gloss" on Colton's map of Texas and Indian Territory. It is pronounced both ways by residents of Oklahoma and southern Kansas.

THE CAVE CREEK FORMATION.—The development of the Cave Creek formation between southern Kansas and northern Texas is practically continuous. The data obtained during the April reconnaissance settled clearly the fact that the Shimer gypsum is no mere local bed, but, as the highest member of the Cave Creek formation, is second only to the Medicine Lodge member and nearly coextensive with the latter within the limits of the formation as at present known. Thus the cave formation is for the most part, as on Cave creek, the southern Kansas locality from which it takes its name, *tripartite* in character. It is magnificently displayed in the great range of bluffs and buttes which I have called the Marcy range, and which constitutes one of the most striking features of the plains topography, stretching almost uninterruptedly from southern Kansas, apparently at least, to the eastern foot-slope of the Llano Estacado, and of which I have elsewhere described the northeastern portion. From Okeene, Oklahoma, this range of bluffs may be seen leaving the Cimarron river in the vicinity of Glass mountains and slowly retreating toward the North Canadian, which the gypsum reaches near Darlington. In one of its canyon recesses, nestles the head of Salt creek. East of Watonga and north of the principal heads of Kingfisher creek, the escarpment gives place to an acclivity of such a grade as to allow a somewhat ready passage for the Kingfisher-Watonga stage-road. With unimportant interruptions due to erosion and blanketing, the outcrop of this great gypsum group extends thence across the Wichita Indian reservation, Washita county, and the southeastern part of Roger Mills county, and is thence continued across either the northern and western parts of Greer county, Oklahoma, and Collingsworth and Hall counties, Texas, or across Gypsum creek of Greer, and Groesbeck creek of Hardeman county (near Quanah); till, reaching the foot-slope of the Llano Estacoda, it pursues for an unknown distance, a course roughly parallel with the eastern escarpment of the latter.* The lowest member of the formation, the Medicine Lodge gypsum, whose western and southern limits are unknown, but which is probably the most extensive bed of gypsum in North America, is usually more conspicuous than the Shimer, owing partly to its greater thickness and partly to the fact that the presence of the Shimer gypsum, at a short remove above it, often continues the cliff-front up to the summit of the formation, so that the Medicine Lodge member is seen cut squarely off in the face of the bluff, while the Shimer is more frequently rounded off or reduced by erosion or concealed by detritus from the overlying Dog Creek formation.

At the head of Salt creek in Blaine county, Oklahoma, the Cave Creek formation has a thickness of 70 or 80 feet, the Medicine Lodge and Shimer gypsum-beds being respectively 18 to 24 and 15 to 18 feet thick, and the interval of Jenkins clay nearly equal to the combined thickness of the gypsums. I was a little surprised to find that the gypsum caves and

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*On the April journey time failed in which to ascertain whether what may be called the *Quanah* gypsum, or what may be called the *Collingsworth* gypsum formation represents the Cave Creek formation in Texas. But it seems certain that the Quanah is a lower gypsum than the Collingsworth, natural bridges of the so-called "Natural Bridge park" (Chapman's amphitheatre) at the head of Salt creek are not developed in any way more strikingly than they are in southern Kansas. Indeed, neither cave nor natural bridge was seen that equalled the Comanche cave or the Bear creek bridge described in my paper on "The Permian System in Kansas," though the roof of one tunnel-like cave, to which I was conducted by Mr. Chapman, serves as a bridge for the passage of a road. This bridge is in the Shimer gypsum, which is the principal cave-forming member of the formation at that locality. Near the upper limit of the brine-spring incline at the head of Salt creek, some of the blocks of gypsum that have rolled down from the Cave Creek brow of the canyon have been curiously fluted by the solvent action of rain.

In his Red River report, in a letter quoted by Pres. Edward Hitchcock on page 160, Captain R. B. Marcy described a great "gypsum-belt" which he stated that he had traced "from the Canadian river, in a southwest direction, to near the Rio Grande in New Mexico," mentioning his observation of it upon the Brazos, Colorado, and Pecos rivers. But on page 99 of the same report, he attributes the belt, on the authority of Maj. Long, to the Arkansas valley also, confusing it with the gypsum of the Marion (Geuda) formation: and in his "Map of the Country between the Frontiers of Arkansas and New Mexico," he makes it cross the Canadian in the eastern portion of the great bends of that river, which would place it in D county, Oklahoma. Nevertheless, I believe that the gypsum-crowned bluffs represented in his "View of Gypsum Bluffs on the Canadian River" (Plate 5) are not those of D county, which are capped with the much higher gypsum herein described as the One Horse gypsum, but belong to the Cave Creek belt and that by some error, the Canadian river segment of this belt was not placed upon the map in accordance with the actual observation of Capt. Marcy, who crossed this portion of the belt in 1849, during his expedition from Fort Smith to Santa Fe. It is impossible to say whether all of the southwestern localities of gypsum which he ascribes to this belt are in the extension of the Cave Creek, as some of his observations may have related to one of the other southwestern gypsum horizons; and it seems more probable that he used the term "gypsum-belt" broadly for an elongate tract of country in which gypsum was common, a use which would imply about the same stratigraphic range as is included in the Double Mountain beds of Mr. Cummins. The Upper Red River map, however, shows clearly that the gypsum of Gypsum and Groesbeck creeks, in adjoining parts of Greer county, Oklahoma, and Hardeman county, Texas, which may be called *Quanah gypsum*, from the town of Quanah, near which it is being utilized in plaster-mills, was not included in the main part of Marcy's gypsum-belt, since the latter, as represented on this map, is far to the west of gypsum creek and Mr. Cummins states that the Permiam of northern Texas dips to the northwest, a direction in which the surface of the country rises.* Whatever doubt may remain as to the relation of outlying parts

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*Overlying the Quanah gypsum, are laminated dolomites, which may be called the *Groesbeck dolomites*, as they are well exposed on Groesbeck creek, in Hardeman county.

of the gypsum belt of Marcy's text to the Cave Creek formation, the portion indicated as the "Great Belt of Gypsum" on his "Map of the Country on the Upper Red River," and extending from the "Gypsum bluffs" and "Gypsum hills," on the North fork of Red river near the camps of June 3rd and 4th, to the South fork near the camps of July 4th and 5th, belongs to the Cave Creek, and the section of the bluffs on the North fork given by Dr. G. G. Shumard of Plate 5 of the Geology of the same report, shows that the formation there has its typical tripartite development.

THE DOG CREEK FORMATION.—The Dog Creek formation persists and finds great emphasis in Oklahoma, being more positive there in its character than in Kansas, and thicker and more complex than the Cave Creek. In central Oklahoma it is a great *dolomite* formation, laminated dolomites occupying a considerable part of its thickness. It is well displayed at the eastern border of the Cimarron-North Canadian Jack sands of Blaine county, particularly so in Chapman's amphitheatre at the head of Salt creek, where it presents a thickness of apparently not less than 100 feet. At this locality, a large body of light gray laminated dolomites forms its upper or Chapman member, its middle and lower parts consisting chiefly of dull red shales with laminæ and one lamina-built amphitheatre ledge of dolomite. The amphitheatre forms a sort of a terrace, or low secondary brow, below the middle of the formation. At the Stony hills,* east of Watonga, the thickness of the Dog Creek is at least equal to that shown at the head of Salt creek and the bodies of thin-bedded to laminated dolomite are similar to those seen at that locality, though perhaps containing some thicker courses and developed more at the expense of the shale. Thus in central Oklahoma the Dog Creek formation differs strongly in character (as in southern Kansas it does plainly, though less strikingly) from the formations which precede and follow it in the Cimarron series.

THE KIGER DIVISION.—The latest observations on the composition of the Cimarron series show that the Kiger division should be restricted to Cimarron rocks higher than the Dog Creek.

During my April trip some observations were made on outcrops of this division on the Canadian river, and through that of September, some details additional to those already published were obtained regarding the western extension of Kiger rocks in the Beaver and Cimarron valleys. It is estimated that there are exposed on the Canadian river, below the great bends, not less than 600 feet of rocks belonging to the Kiger; and westward, higher beds, partly concealed by Cretaceous and Neocene rocks may add to this thickness an unknown amount. The exposed thickness of Kiger rocks on the Beaver river and its suc-

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*There are several reasons why *Stony Hills* is a better name for this dolomite formation than *Dog Creek*, one of which is that the Dog creek of Barber county, Kansas, is often called *Monument creek*. A second is that another Dog creek in Oklahoma, nearer to the typical dolomite development of the formation, like that Dog creek of Barber county, cuts chiefly below the formation. A third is that the Stony Hills show a splendid development of the rock that is especially characteristic of the formation, which the Barber county locality does not. The name should perhaps be changed for these reasons.

cessor, the North Canadian, is more limited, and on the Cimarron river still more so, in accordance with the general northward contraction of the Permian area of the Plains. On the north side of the Beaver the most westerly outcrops of the Kiger were seen in a bluff cut by this stream at Mr. John George's place, about six miles west of Beaver City, and in a less conspicuous exposure some three miles east of the mouth of Sharp's creek. On the south side, beginning with the red shales and plum-pudding gypsum that I have previously reported on Clear creek,* outcrops of red and more or less mottled shales and sandstones of this division were found on Home, Six-mile, Dugout, Willow, and Jackson creeks, and were reported to occur as far west as Fulton creek, four miles west of Fulton post-office. On Jackson creek the beds of the Kiger present strong dips, a feature common in the Red Bluff formation of Clark county, Kansas, and one upon the possible causes of which I have elsewhere commented. In one left-side exposure a mile or two above the mouth of the creek, I measured a southerly dip of 28 degrees, in another, about a quarter of a mile farther up the creek, this southerly dip finds its complement in a northerly one somewhat less steep. The summit of the syncline thus indicated is concealed by Neocene deposits. Anticline-like undulations are seen in a larger right-hand bank of the red rocks still farther up the creek, just below the Rothwell-Boyd mail road. The Kiger rocks there are also more or less fractured, and the fissures are partly filled with seams and nests of limpid calcite.

I first observed these Beaver county red-beds and their included gypsum on Clear creek, a short distance southeast of Beaver City, in 1890. I briefly noticed them in 1891 in my paper, "On a Leaf-bearing Terrane in the Loup Fork," (AMERICAN GEOLOGIST, vol. VIII, p. 29,) where, in accordance with the view then prevailing, I referred them to the Triassic, and again in "The Permian System in Kansas," where I recognized their Permian age and placed them in the Cimarron series, but was uncertain whether the gypsum should be referred to one of those of the Cave Creek formation or to a higher horizon. The gypsum horizon seen on Clear creek is now known to be well up in the Kiger division and, from its occurrence near Beaver City and in the county and river-basin of Beaver, I propose to call it the *Beaver gypsum.* A thin band of gypsum which I recently observed on Home creek and a six-foot bed which I failed to see, but which, according to Mr. J. J. Fulkerson, outcrops on the south side of the Beaver opposite Sharp's creek, and a ledge on the west prong of Jackson creek, which Mr. Fulkerson states to be the most westerly gypsum that he has seen in the Beaver valley, may all belong to the horizon of the Beaver gypsum, though I cannot say from the observations thus far made, that none of these is any higher. It is interesting to note that the Hades creek bed and the Beaver bed, the two in which the plum-pudding structure has been especially noticed, are both in the upper division of the upper series of the Permian; but I have elswhere noticed the occurrence of dark and transparent crystals in the gypsum of the Cave Creek formation on the Cimarron river and Salt fork.

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*In "The Permian System in Kansas," I referred to a peculiar feature well shown in part of the gypsum on Clear creek as resembling "plums in a pudding." I find that in the Second Annual Report of the Texas State Geological Survey, Mr. W. F. Cummins had earlier mentioned a "plum-pudding" gypsum in the Permian of Texas, "containing small round crystals" and apparently like that on Clear creek except in not having the "plums" salmon-colored. Only a part of the ledge on Clear creek shows the plum-pudding structure well, and the plums in that are not all salmon-colored; but when the structure and color both appear, and especially where a weathered surface can be found, the rock makes beautiful cabinet specimens.

On the Cimarron drainage, Kiger rocks outcrop at intervals deep down in the valley of Crooked creek, appearing farthest up the latter opposite Boyer's ranch, nine or ten miles below Meade, where it forms a low bank at the foot of the east incline of the valley. These rocks undoubtedly underlie the "Salt well" southeast of Meade at no very great depth. They outcrop for a considerable distance in Slick canyon, a dry branch on the south side of the Cimarron river, west of Taintor's creek. This is the most westerly occurrence of the Kiger that I have seen in the south side of the Cimarron valley.

It was formerly thought that a remnant of the Kiowa shales might possibly be found covering the Kiger rocks on the upper-middle part of the Big Sandy creek drainage; but such is not the case. On this drainage the Kiger is everywhere overlaid with fresh-water Neocene rocks which are largely calcareous sandstones, but which sometimes (as on the right bluff of the creek, near the mouth of Gyp creek) consist of peculiar yellowish-green and chocolate-colored clays, there being an entire absence of the Kiowa formation in Kansas west of the interval between Big and Little basins. So far as observed, the covering of the herein-described Kiger rocks of the eastern part of Beaver county, Oklahoma, is also Neocene.

The Red Bluff Formation.—Below the brow-rock, the entire body of the Red hills (sometimes and more fittingly called "the Red bluffs") south-southeast of Watonga, Oklahoma, belongs to the Red Bluff formation. These hills rise 200 feet or more above the North Canadian river, 150 feet of which is in the bluff proper and the remainder in the basal slope. But the character of the Red Bluff formation as found in these hills, differs from that seen in Kansas. At the Red hills the upper 50 or more feet of the formation consists of relatively firm red sandstone, laid in courses two to four feet thick, and locally charged with concretionary balls of iron-sandstone, some of which have been set free from the inclosing rock by the dissolving of a peripheral layer and rattle in their spherical cavities as one handles a piece of the rock containing them.

On Two-mile creek, in the southeastern part of Meade county, Kansas, the summit of the Red Bluff formation does not show the bright red color that marks the body of this formation further eastward; but this color appears at a little lower level in the bed of the creek, in one of the "squared-off" banks of fine marly-textured sandstone so characteristic of the Red Bluff in Clark, Comanche and Barber counties.

The formation is more or less saliferous. Manifestations of this are seen in the salt efflorescence on rocks in the bed of Johns and other creeks near Cash City, and of Crooked creek near Odee, and other streams of this region where the ground-water is in or in communication with the upper part of the Red Bluff, including the great salt well near Meade, the porous, sunken mass of whose floor undoubtedly reaches down to a contact with Red Bluff walls. Indeed, it is not improbable that the cavity by whose collapse (in March 1879) this "well" was produced, was in the Red Bluff formation and owed its existence to the action of subterranean waters which literally *mined* the saliferous shale, dissolving the salt, and (since the buoyancy, and so the transporting power, of brine is greater that of fresh water) probably carrying off with the brine minute particles of the shale itself; and it seems probable that St. Jacob's well and the other "drops" in Little and Big basins and in Comanche county have been formed in a similar manner.*

THE DAY CREEK DOLOMITE.—In the western part of Clark and in Meade county, Kansas, the Day Creek formation loses its typical character. It is there represented by a band of greenish-gray to red and gray sandstone with occasional streaks of dolomite. This band is not always well differentiated and is often concealed by talus, but appears as a soft greenish-gray sandstone, twenty-five feet below the Big Basin sandstone, in a deep right-hand canyon of Big Sandy creek (containing a row of dugouts and a well) a little below the junction of Big Sandy and Gyp creeks. On Two-mile creek, farther southwest, it appears as a two-foot bed of red and gray sandstone similar to the Big Basin sandstone and at the same distance below it. At Odee post-office, in Meade county, a thin local ledge of reddish-gray, pisolitic and stalagmitic-appearing rock outcropping in a left-hand ravine of Crooked creek northeast of the house of Mr. Petefish, is apparently not far from the horizon of the Day Creek, and may possibly represent it in that quarter; but such an identification is very doubtful, and the true position of this ledge will require more exact observations than any I have yet had opportunity to make.

From this loss of typical character which befalls it in the most westerly outcrops of the Kiger division in Kansas and from its moderate thickness, one might be ready to infer that the Day Creek is an unimportant formation. Such a conclusion would be erroneous, as the extent of this dolomite in essentially its typical phase is very much greater in the general southwesterly course of the Cimarron outcrops than east and west, and it is probable that the horizon of its modified western extension in southern Kansas can usually, if not always, be identified where its position is exposed and where due care is exercised in the observations. The brow of the Red hills near Watonga, Oklahoma, is coped with the Day Creek dolomite, which there presents itself as a compact stratum of gray, somewhat pinkish or reddish-tinged, cherty-hard rock, little different from the typical ledge that skirts the flanks of Mount Lookout in Clark county, Kansas. The stratum has a thickness of three feet. How far the Day Creek dolomite can be traced beyond the Red hills in the general southwestward range of the Cimarron series, I did not ascertain; but from the summit of these hills the eye may follow the ashen ledges of its sinuous outcrop southward till distance dissolves them in the general landscape.

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*Drops or sink-holes, are also formed by the collapsing of gypsum-caves, but the gypsum is usually "in evidence" in such cases.

THE TALOGA FORMATION.—On Two-mile creek and other parts of the Big Sandy creek drainage in adjoining parts of Meade and Clark counties, Kansas, the Hackberry shale scarcely differs from the rocks of the Kiger which appear there above the Big Basin sandstone. This sandstone maintains its full thickness as far west as Johns creek, on the right side of which it is still the highest bed of the Kiger in some forty-five feet of that division that appears in a bluff about a mile southeast of Cash City.* Here it presents a tripartite color-phase, its eight to twelve feet of thickness being mostly red, but about two feet at the base and a like amount at the summit being gray. West of Johns creek it is thinner. It appears in a left-side bluff of lower Gyp creek, but with only the lower and gray zone developed as quarry-rock, the remainder passing into shale. Several of the buildings of Englewood and Cash City have been made from the Big Basin sandstone of Gyp and Johns creeks, chiefly in the gray color. On the west side of Big Sandy creek, below its junction with Gyp creek, the thickness of this sandstone is only five to seven feet, and on the south side of Two-mile creek, where a high bluff exposes a few score feet of Kiger rocks, it is reduced to three feet.

Owing to the lateness of the hour of my visit to the red hills of Blaine county, Oklahoma, time sufficed only for the examination of their northeast section, and the rocks which succeed the Day Creek dolomite immediately to the westward were not observed closely enough to afford positive knowledge of their character. But rocks belonging to the position of the Hackbery shale and Big Basin sandstone and, farther westward, others belonging to still higher horizons of the Kiger division are visible from the summit of these hills.

The persistence of typical Hackberry shale and Big Basin sandstone in central Oklahoma is at least doubtful, while observations made southwest of Watonga and on the South Canadian river, in D county reveal a great thickness of Kiger rocks above the Day Creek dolomite, in this part of Oklahoma. For this reason a three-fold parting of the Kiger division seems to be the only practicable one, if we restrict this division to Cimarron rocks higher than the Dog Creek. Thus the formations of the Kiger division would be: the lowest, or Red Bluff; the middle, or Day Creek; and the highest, or *Taloga*; the latter named after the town of Taloga, county seat of D County, Oklahoma, being here proposed to include all of the Kiger rocks above the Day Creek.

In west-central Oklahoma, some of the red rocks of the Taloga present a remarkable resemblance to those of the Red Bluff formation which are seen in the northeastern part of Barber county, Kansas, having the same texture and intensely red color, and giving rise to the same peculiar soft and loamy and "brick-dust" soils which there characterize the latter formation. Only two horizons of the Taloga observed in that part of Oklahoma need here be especially designated. These are both of gypsum of poor quality, and belong to the bluffs that rise on the south side of the Canadian river, in "D" county, in view from the post-office of Butte. One of these appears in the brow of the bluffs, about ? 250 (between 215 and 285) feet above the river, and has a thickness of 3 or 4 feet. The other, much more limited in horizontal extent, occupies a position 90 or 200 feet lower, and has a thickness of only a foot or two, but is underlain with 4 or 5 feet of red gypsum-clay. They may be called respectively the *One Horse* and the *Old Crow* gypsum after the two fords of the Canadian river which (after Indians resident near them) are known as the "*One-Horse* crossing" and the "*Old Crow* crossing," the upper bed being named from the upper ford,—One Horse—and the lower from the lower. The One Horse horizon has been followed for only a short distance, but is probably a horizon in the sense of a stratigraphic level in which gypsum is continuous or recurrent within a considerable extent of outcrop. The Old Crow gypsum appears to be only a small lens. It is not yet known whether either of these gypsum beds may approximately correspond in position with the Beaver gypsum of Beaver county, as the elevations all above the base of the Kiger, are unknown. That all three horizons are in the Kiger division, and that those of "D" county are well up in the Taloga formation, is all that can now be considered certain; but there are some considerations that seem to indicate a lower position for the Beaver.

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*The Cash City referred to in this article is the later location of the town. It is now the ranch of Mr. B. H. Campbell.

In closing, I present in tabular form what, in the light of these new and all earlier observations, seems to be the most broadly adaptable

CLASSIFICATION OF THE ROCKS OF THE CIMARRON SERIES.

Divisions.	*Formations.*	*Subformations.*
KIGER.	*Taloga.*	Quite variable with locality.
	Day Creek.	None.
	Red Bluff.	None determined.
SALT FORK.	*Dog Creek.* (*Stony Hills.*)	*Chapman dolomite. *Amphitheatre dolomite.
	Cave Creek.	Shimer gypsum. Jenkins clay. Medicine Lodge gypsum
	Glass Mountain.	Flower-pot shales. *Cedar Hills sandstone.
	Kingfisher.	Salt Plain. Harper.

Colorado Springs. F. W. CRAGIN.

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*Starred subformations in the table are not known to be clearly recognizable outside of the type locality.

PERSONAL AND SCIENTIFIC NEWS.

MR. T. A. RICKARD, mining engineer and metallurgist, of Denver, has been reappointed, by Gov. Adams, State Geologist of Colorado for a second term.

DR. WILLIAM JOHN SOLLAS, F. R. S., professor of geology in the University of Dublin, has been elected to the chair of geology at Oxford, which was held by the late Prof. Green.

PROF. A. LACROIX of Paris reports an abundance of *lawsonite* as a constituent of saussurite gabbros and certain glaucophane schists of Corsica. He will present a note on this subject in the next (No. 3 of vol. 20) Bulletin of the French Society of Mineralogy.

THE PENNSYLVANIA STATE COLLEGE has erected on its grounds a "geological polylith" composed of a large number of blocks of the various building stones of the state. The monument is intended to exhibit these building stones and to furnish a means of noting the effects of the atmosphere on them. Thin sections and analyses of the various stones are preserved for reference.

AT A MEETING HELD APRIL 13 the Academy of Natural Sciences of Philadelphia conferred the Hayden Memorial Award for 1897, consisting of a bronze medal and the interest of the special endowment fund, on Prof. A. Karpinski, the chief of the geological survey of Russia, in recognition of the value of his contributions to geological and paleontological science.

WITHIN THE PAST MONTH American geology has suffered the loss by death of two workers, Dr. Jos. F. James, at Hingham, Mass., March 29, and Prof. Edward D. Cope, who died April 12th at Philadelphia, Penn. The former was known for his numerous contributions to the geological literature of the country, and the latter for his contributions to the vertebrate paleontology of America, as well as the long-time editor-in-chief of the *American Naturalist.* Appropriate sketches of these geologists will be given in future numbers of this journal.

DR. CHARLES R. KEYES informs us that as evidence of its appreciation of the work of the Missouri Geological Survey the General Assembly of that State recently passed the bill providing for the support of the bureau without a dissenting vote in either house. Inasmuch as this was the only bill carrying an appropriation that was not cut either in committee or on the floor of the houses, the inference is clear that at least one State legislature, even in troublesome and depressing times when the spirit of "retrenchment and reform" is abroad, did not consider that the geological survey was a place wherein it would be possible to legitimately economize, or that a survey is a luxury that a State may well do without. This action is in marked contrast with that of some legislatures that have been in session this winter.

The Academy of Science of St. Louis. Meeting on March 15, 1897. President Gray in the chair, present also thirty-five members and guests. A portrait of Dr. Enno Sander, who for the past thirty-five years has served uninterruptedly as its treasurer, was presented to the Academy. Dr. Hambach spoke entertainingly and instructively on what a geologist may find of interest about St. Louis, exhibiting specimens of the principal fossils and minerals characteristic of the local deposits, and indicating the best localities for the collection of certain specimens. William Trelease, *Secretary*.

At the meeting held on the 19th of April, Dr. C. Barck delivered an address on Helmholtz—his life and work; and Dr. C. R. Keyes, the State Geologist of Missouri, presented papers on the relations of the Devonian and Carboniferous systems of the upper Mississippi basin, and the distribution of the Missouri coals.

The California Academy of Sciences has adopted a new method of publication. Heretofore three publications,—Proceedings, Memoirs and Occasional Papers,—have been issued, but hereafter the Memoirs will be discontinued and the Occasional Papers will be retained for the publication of extensive monographs at such times as they may be presented and the funds of the Academy will permit. The Proceedings will be retained and the new series (the third) will be issued in wholly independent divisions, each devoted to a single science or to a group of very closely related sciences. The divisions already established are for geology, for botany and for zoology, and it is probable that a mathematico-physical division will be added shortly and others as required. No. 1 of the geological division ("The geology of Santa Catalina island" by W. S. T. Smith) has already been issued. The divisions of the Proceedings will be formed into volumes of generally 400 to 500 royal octavo pages. The subscription to the geological volume is $4.00, which should be sent to J. O'B. Gunn, Corresponding Sec'y, Cal. Acad. Sci., San Francisco.

Reception to Sir Archibald Geikie. A meeting of the N. Y. Academy of Sciences, section of geology was devoted to a reception of the whole Academy to Sir Archibald Geikie, director-general of H. M. geological survey of Great Britain, who has just returned to this country for a brief visit after an absence of eighteen years. After an informal reception the meeting was called to order and addressed briefly by the president of the Academy, Prof. J. J. Stevenson, who extended a most hearty welcome from the scientists of New York to the guest of the evening. Prof. Stevenson was followed by Prof.

J. F. Kemp, the chairman of the section, who reviewed in a few words the greater contributions of Sir Archibald Geikie to the cause of geology. He spoke of his early work in Scotland, in France and in the western United States in the study of vulcanism, and paid particular attention to the work that had been done in Scotland on the metamorphic rocks. Prof. Kemp concluded with a tribute to Sir Archibald as a naturalist and spoke of the superior quality of work that is given the world by the man who is in love with nature and finds in the solitude of the wildness of nature his greatest company and inspiration.

The next speaker was the secretary of the section who spoke particularly of the work of Sir Archibald Geikie as looked at from the standpoint of the teacher and physiographer. He reviewed hastily the character and quality of Geikie's text book and class book of geology and spoke more especially of the example this distinguished geologist has set in physiography in the masterly analysis of the physical features of Scotland given in his Scenery of Scotland.

The last address was given by Prof. Angelo Heilprin of Philadelphia who spoke as a traveler and contrasted the knowledge of the geology of the world now with our knowledge at the time of Humboldt. He spoke of how much we owed to the guest we were welcoming for his work in bringing together the shreds of knowledge from all parts of the world and in building up a great mass of geological information, which is a vast help to all workers in geology and a stimulus to all.

In reply Sir Archibald Geikie expressed his thanks to the Academy for the very cordial reception that had been tendered him in New York. He contrasted the appearance of the city eighteen years ago and now and spoke of the great growth of the city vertically as well as horizontally. He paid a brief tribute to his friends of his former visit. particularly Newberry, Leidy, Dana, Cope and Hayden, whose help and good will have ever been a great inspiration to him.

In reviewing the work of world wide reputation that the American geologists are producing Sir Archibald Geikie paid a warm tribute to their industry, their perseverance, their breadth and to their scientific acuteness. He contrasted in a very favorable way to the United States the policy of the British and United States Governments in regard to the printing, publishing and distribution of government reports.

After these brief addresses an opportunity was given for meeting the guest of the evening; for personal and social meetings among the members of the Academy and for greeting the guests from a distance, including several well known geologists. RICHARD E. DODGE, Secretary.

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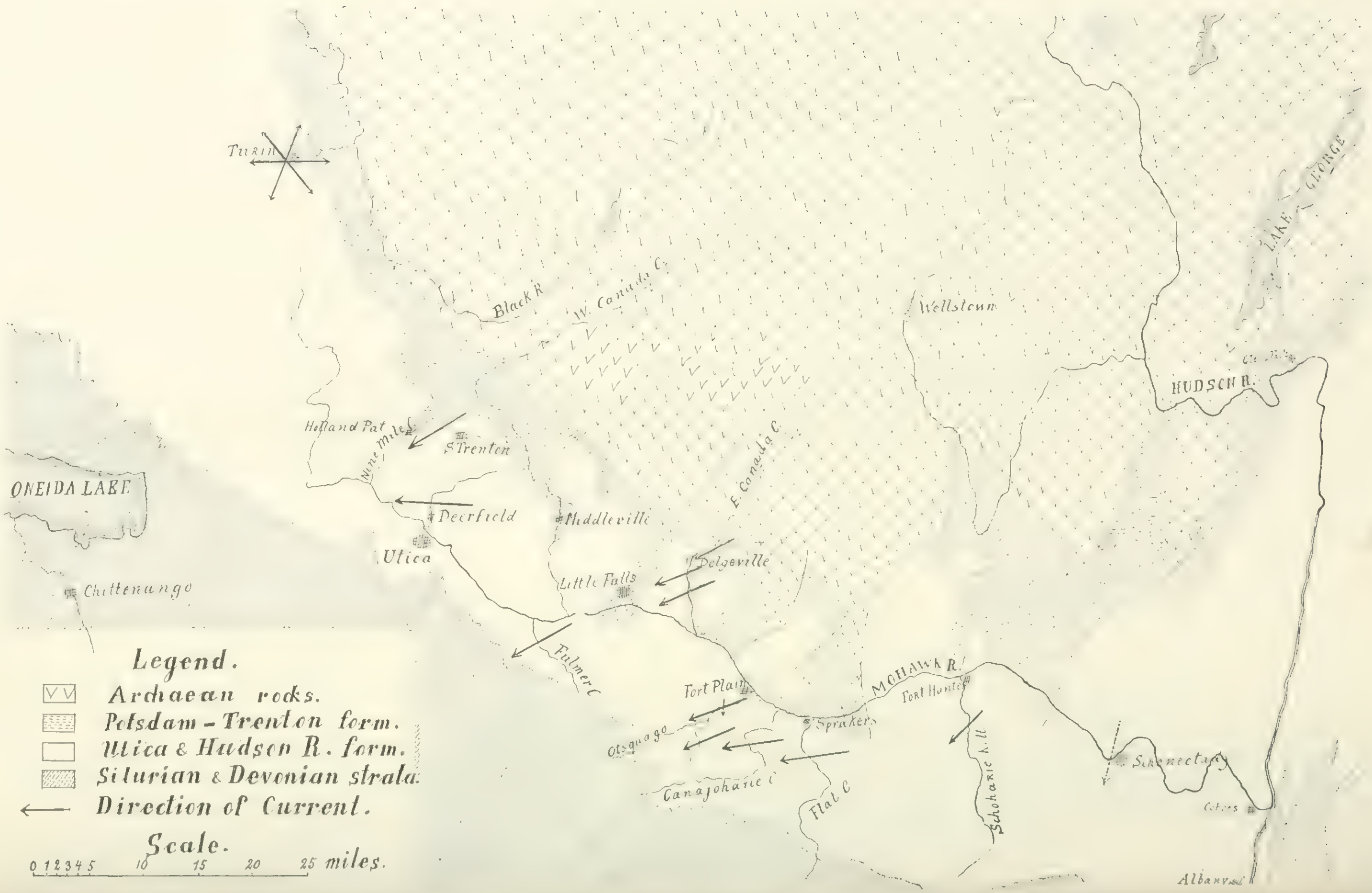
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EVIDENCE OF CURRENT ACTION IN THE ORDOVICIAN OF NEW YORK.

By R. RUEDEMANN PH. D., Dolgeville, N. Y.

Plate XXII.

The remarkable parallel arrangement of the rhabdosomes of graptolites, spicules of sponges, fragments of bryozoans and shells of *Endoceras proteïforme* in the Utica shale near Dolgeville, N. Y., has been noticed by the writer ever since he has studied this terrane, but it was not given any special attention, as it was supposed to be due only to local and changing movements of the water. The observation, however, that these fossils, through a whole series of beds of shale and intercalated limestone, pointed apparently in the same direction suggested the tentative measuring of the directions of the fossils in this series, which examination gave the result that all pointed nearly in the same direction, viz. *E. N. E.* It was soon found that this direction is kept in all shales exposed in the neighborhood of Dolgeville. This again suggested that the phenomenon might be of more than local importance. The writer, therefore, made excursions to the exposures of the Utica shale in the Mohawk and Black River valleys. The results of these excursions are seen in the submitted tables, which show that those shells which can be easily displaced by moving water, show a general E. N. E.–W. S. W. bearing in the Utica shale of the Mohawk valley.*

Section on first curve of East Canada Creek, below Dolgeville.

The rock is thin-bedded shale and slate with occasional intercalations of thin calcareous bands.

1. Four layers of shale, with crinoid joints, sponge spicules, specimens of *Climacograptus bicornis* and a few *Endoceras* shells. Bearing of all, N. 70 degrees E. The apices of the *Endoceras* shells point E.

2. Above a layer covered with fragments of *Triarthrus*, all directed N. 60 degrees E.

Fourteen surfaces of shale exposed, with sponge spicules, *Diplograptus pristis* and *Endoceras*. Bearing, N. 60–70 degrees E. Graptolites point E. with the sicular ends and *Endoceras* shells with the apices.

Bank of limestone (without fossils).

3. Shale with fragments of *Triarthrus*, all directed N. 50–70 degrees E., giving the slabs a furrowed appearance.

Eight surfaces with prevailing sponge spicules, a few *Diplograptus pristis* and *Endoceras*, all pointing N. 50-70 degrees E. Apices of *Endoceras* shells E.

Layer with sponge spicules and numerous rhabdosomes of *Climacograptus bicornis*. Bearing, N. 65 degrees E. Sicular ends of most stipes west.

Calcareous bank, without fossils.

4. Eight layers with numerous specimens of *Endoceras*. Bearing, N. 70 degrees E. Apices E.

Layer with trilobite fragments, numerous specimens of *Climacograptus* and some *Endoceras* shells. Bearing, N. 50-60 degrees E.

Layer with *Climacograptus bicornis*. No direction.

Layer with *Climacograptus* and *Endoceras*. Bearing, N. 70 degrees E. Fourteen shells of *Endoceras* were counted pointing east, two west. Apices of *Climacograptus* in both directions.

Numerous layers with *Diplograptus pristis* and *Climacograptus*. Bearing, N. 60-70 E. Sicular ends mostly west.

Calcareous bed, without fossils.

5. Four layers full of sponge spicules. Bearing, N. 80 degrees E.

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*It is to be remarked that layers which yielded no fossils at all or only single specimens of the displaceable fossils have not been mentioned; further that among the given bearings are certain ones to which the fossils are almost mathematically parallel (especially in certain layers near Dolgeville and on Otsquago creek), while in other layers there is only a general, though distinct tendency to arrangement in a certain direction. In the latter case the limits of the directions have been given. It is evident that the differences in the regularity of the arrangement are due to differences in the velocity of the moving water.

The approximate value of 10 degrees for the present western magnetic declination of the needle in the middle Mohawk valley has been used for the correction of the readings.

Bed with prevailing spicules, some shells of *Endoceras* and *Climacograptus*, gathered in patches. Bearing, N. 50 degrees E.

Calcareous bed.

6. Many layers densely covered with fragments of *Triarthrus*. Bearing, *due east.*

Two beds with *Climacograptus*. Bearing, *due east.* Sicular ends, W.

Layer with *Triarthrus* fragments, *Climacograptus* and *Endoceras*. Bearing, N.. 70 degrees east. Apices of *Endoceras* and sicular ends of *Climacograptus* E. (14 *Endoceras* shells E., none W.)

Layer with the same fossils, but 8 *Endoceras* W., 3 E. The numerous sponge spicules and *Endoceras* shells in this layer are directed N. 70 degrees E., while the rhabdosomes of the graptolites are parallel to N. 15 degrees E. The appearance of this layer, which is exposed over a large surface, suggests the directing action of two successive motions of water of different strength.

Layer with *Endoceras* and *Climacograptus*. Bearing, N. 70 degrees E. The apices of the *Endoceras* shells point east (41 E., 3 W.); those of *Climacograptus* in both directions.

Numerous layers with trilobite fragments and rhabdosomes of *Climacograptus*. Bearing, N. 85 degrees E. Sicular ends in both directions.

Layer with spicules, N. 85 degrees E.

Numerous layers with trilobite fragments. Bearing, N. 85 degrees E.

Layers with *Triarthrus* fragments, spicules and long drift-ridges of fragments of *Diplograptus pristis* and *Lingula*. Bearing, N. 80 degrees E.

Layer with spicules and shells of *Endoceras*. No distinct direction.

Bed of calcareous shale. This bed is covered with projections, each consisting of a round nucleus from which proceeds a gradually broadening and flattening ridge. The bearing of these ridges is N. 80-90 degrees E., the nuclei being towards the east. The latter generally contain some small fossil, usually a gasteropod. It is evident that the ridges result from the deposition of fine calcareous mud behind the shells, and, therefore, allow the inference that the water came from N. 80-90 degrees E.

7. Numerous layers with sponge spicules. Bearing, N. 60 degrees E.

Layer with furrows, as from flowing mud, running N. 60 degrees E.-S. 60 degrees W.

Layer with *Triarthrus* fragments, crinoid joints, and sponge spicules. Bearing N. 60 degrees E.

Eight layers with sponge spicules and rhabdosomes of *Climacograptus*. Bearing, N. 70 degrees E.

Layer with *Climacograptus bicornis* and *Endoceras*. Bearing, N. 65 degrees E. Apices of *Endoceras* shells E.

Five sponge beds. Bearing, N. 75 degrees E.

Two layers with *Triarthrus* fragments and *Endoceras* shells. Bearing, N. 80 degrees E. All *Endoceras* shells point E.

Six sponge beds. Bearing, N. 55-70 degrees E.

Layer with *Triarthrus* fragments and spicules. Bearing, N. 60 degrees E.

Calcareous bed.

8. Layer with trilobite fragments. No direction.

Layer with *Diplograptus pristis.* Bearing, N. 60-70 degrees E.

Numerous layers with *Endoceras* shells. Bearing, N. 55-65 degrees E. All point east except in one layer where 5 point west and 2 east.

9. Layer with trilobite fragments, rhabdosomes of graptolites and casts of *Trochonema.* Behind the latter there are drift lines of fragments and before them lie fossils in a transverse position, as if arrested while drifting. The motion of the water must here have been quite strong, as the slabs appear furrowed in a parallel manner by the fossils. Bearing, N. 62 degrees E. Drift-lines extend towards S. 62 degrees W.

Layer with *Endoceras.* Bearing, N. 65-70 degrees E. Two were seen to point east, none west. Behind the *Endocoras* shells, towards the west, drift-lines of trilobite fragments, etc., are found.

Layer with *Endoceras.* Bearing, N. 70 degrees E.

Calcareous bed, contains some complete specimens of *Triarthrus becki*, while in the shale only dislocated fragments are met with. This difference in the preservation is probably due to the different velocity of the depositing water, the calcareous mud being a still-water deposit.

10. Three layers with *Diplograptus pristis.* Bearing, N. 60 degrees E. Sicular ends point both ways.

Layer with *Endoceras.* Bearing N. 75 degrees E. 6 point east. 2 west.

Layer with *Diplograptus pristis.* Bearing, N. 70-80 degrees E.

Layer with fragments of *Triarthrus* and scattered rhabdosomes, arranged in a general easterly direction, but not so strictly as to approach parallelism of the fossils.

Layer with numerous large *Endoceras* shells. Bearing, N. 35 degrees E. 36 pointing east, 2 west.

Layer with many rhabdosomes of *Diplograptus pristis* arranged in long drift-lines running N. 80 degrees E., while many stipes outside of the drift-lines point in various directions.

Below a great many layers with outcrops too narrow to give sufficient evidence. The rhabdosomes observed show an easterly direction.

Calcareous bed.

11. Three layers densely covered and parallel striated by specimens of *Diplograptus pristis* and *Endoceras.* Bearing, N. 70-75 degrees E. Apices of the fossils eastward.

Layer with *Diplograptus pristis.* Bearing, N. 80 degrees E. Apices east.

Layer completely furrowed by rhabdosomes of *Diplograptus pristis.* Bearing. N. 80-90 degrees E.

Layer exposed with large surface, on the whole of which the direction of the rhabdosomes shows no change. Bearing, N. 70 degrees E.

Layer with shells of *Endoceras.* Bearing, N. 65 degrees E. Four point east, none west.

Three layers with mud-flow structure and rhabdosomes of *Diplograptus*. Bearing, N. 75 degrees E. Apices or sicular ends point east.

Two layers with *Diplograptus pristis*. Bearing, N. 70 degrees E.

Layer with mud flow and *Endoceras*. Bearing, N. 77 E. Nine *Endoceras* shells point east, none west.

Two layers with *Endoceras*, all point N. 60 E. Behind the apertures of the shells are piled up smaller shells of *Endoceras*, gasteropods and brachiopods.

Layer full of shells of *Endoceras*, all exactly parallel in N. 63 degrees E. direction, the apices being east. The shells are arranged in rows and connected with long mud ridges extending from the shells towards the southwest.

Layer with *Endoceras* shells, 2 S. W., 4 in differing directions.

Layer with rhabdosomes of *Diplograptus*; no direction.

Layer with spicules of sponges, *Endoceras* and small brachiopod shells, (the latter with their beaks toward east). Bearing, N. 65-70 degrees E. 6 *Endoceras* shells pointing east, none west.

Calcareous bank.

12. Seven feet of shale, containing: Layer with *Diplograptus*, *Endoceras* and spicules. Bearing, N. 76 degrees E. Ten shells of *Endoceras* point east, one west. Apices of graptolites point east.

Seven layers striated by parallel spicules; besides numerous graptolites and some shells of *Endoceras*. Bearing, N. 65-70 degrees E. Shells of *Endoceras* point east.

Layer with spicules and *Endoceras*, the latter lying N. 30 degrees E, and 6 pointing west, 1 east. The sponge spicules, however, show in some places the same direction, in another place their bearing is N. 60 to 70 E., and in other places they lie in all directions. There was, therefore, apparently no general equal motion of the water or the flow was so slow that it had no constant directing influence.

Two layers with *Endoceras* (a small surface only exposed). Bearing, N. 70-80 degrees E. 8 point east, 2 west.

Layer with *Endoceras*. Thirteen specimens arranged in N. 50-80 degrees E. direction, 4 others under right angles to these directions. The apices of 12 of the former specimens are directed toward west. As the 4 specimens with varying directions show, there was no constant directing, or a very weak directing force.

Layer with *Endoceras*. Bearing, N. 80 degrees E. Seven directed eastward; none westward.

Three layers of *Endoceras*. Bearing N. 80 degrees E. Two point west, six east.

The average of the bearings observed in this whole section which comprises some twenty-four feet of shale, is N. 68 degrees E., or a direction falling near E. N. E.

Continuous with this exposure is another one in the overlying rock. A few layers of the latter are exposed over a large surface and show distinctly the parallel direction of the numerous shells of *Endoceras* which they contain. The bearing is N. 60-80 degrees E. and the apices lie towards the east. On the tumulus, slabs with well-preserved rhabdosomes and whole colonies of *Diplograptus pristis* are found. The rhabdosomes point in all directions, in accordance with the observation made in other localities, that, wherever colonial stocks are preserved, the water was not in fast motion during the deposition of the sediment.

Following the creek along the left bank over the "High falls" we meet with the exposure which furnished the rhabdosomes and colonies of *Diplograptus ruedemanni** and the sessile specimens of *Conularia gracilis*.† The shales are here, on account of a dyke which approaches the creek from east, in too steep a position to furnish conclusive readings of the directions of the numerous graptolites. Yet the locality is of great importance because it exhibits large surfaces completely covered with the parallel arranged small rhabdosomes of the above mentioned graptolite. The continued action of the directing force during the deposition of many layers is, therefore, here more strikingly exhibited than anywhere else. The most important layers are the following:

Layer of shale with numerous broken fragments of a bryozoan (*Stictoporella*), all parallel.

Layer with colonies of *D. ruedemanni*, no direction.

Two layers, densely covered with rhabdosomes of *D. ruedemanni*, all parallel and pointing east with the sicular ends.

Layer with fragments of trilobites and bryozoans and shells of *Endoceras*. Parallel arrangement, the apices of the *Endoceras* shells pointing east.

Layer with rhabdosomes of *D. ruedemanni* in great multitudes; all sicular ends point east.

The fossils in these layers all show the same direction, which, under the supposition that the strata have only been tilted and not twisted, is in the neighborhood of E. N. E.

It is worth mentioning that in the same locality, a little higher in the series of interstratified shales and limestone banks, a layer is exposed which shows the rhabdosomes of *D. ruedemanni* pointing west, instead of east, as in the other layers. The direction is N. 40-50 degrees W. As the exposed surface is only small (53 graptolites have been counted) it could not be ascertained whether this opposite flow of the water was of wide extent or only the result of a small local eddy.

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*Cf. Amer. Jour. Sci., 1895, p. 453; Jour. of Geology, 1896, p. 307.

†AM. GEOL., 1896, vol. XVII, p. 159, and vol. XVIII, p. 65.

Farther down the creek, in the gorge below the High falls, some 80 feet of shale are exposed, only the lower part of which is accessible. This as well as the numerous other exposures of Utica shale along the creek, is instructive on account of the regular alternation of shales and banks of limestone which it exhibits. The readings which could be obtained in these exposures from the graptolites, bryozoans and the mud flow structure, ranged between N. 60 degrees E. and N. 80 degrees E. and gave as an average the E. N. E. direction, the bearings towards N. 60 degrees E. being the more common.

"*Flat Falls*" *of East Canada creek.*

Here the change of the Trenton limestone into the Utica shale is well exposed. The regular succession of limestone bands and shales becomes here still more apparent than above. The writer sees from his notes that he counted and measured, beginning from the typical Trenton limestone, 95 regular alternations. While, at the base of this series the intercalations of shale are still very thin (a few inches), they increase in thickness towards the top, while the bands of limestone decrease at the same time. Together with the gradual change of the rock, a change in the fossils takes place. The Trenton limestone here is rich in very large, conical and branched specimens of *Monticulipora lycoperdon*, fragments of *Isotelus gigas* and *Calymene senaria* as well as in the Trenton brachiopods, while some bands consist entirely of crinoid joints. *Monticulipora* shows the first and most marked change, in becoming smaller before disappearing, while the trilobites and brachiopods disappear without apparent change. In the ninth intercalation of shale two specimens of *Diplograptus pristis* were found, while *Calymene*, *Orthis testudinaria* and *Monticulipora* still continue in the superjacent limestone. At the 17th intercalation, the last specimens of *Monticulipora* were noticed, and *Calymene* alone continued further. The 51st intercalation of limestone consisted entirely of crinoid joints. The shales in all these alternations up to the 50th, are almost barren, only an occasional *Diplograptus pristis* being met with. Then, heads of *Triarthrus becki* appear and soon become common in the shale, while the limestone begins to contain the whole carapax of the same animal. The rhabdosomes of *Diplograptus pristis*, though met with in the 58th and 61th stratum of shale (in the latter also some specimens of *Endoceras proteiforme* and *Trochonema* were observed) do not become common until the 69th stratum of shales, where they, however, show no direction.

In the 75th intercalation of shales *Diplograptus ruedemanni* appears in great abundance, together with a few specimens of *Endoceras proteiforme.* The bearing is N. 82 degrees E., and the apices of the fossils point eastward.

Above this shale, however, a layer of shaly limestone appears unexpectedly, which consists largely of crinoid joints, fragments of *Isotelus gigas* and the brachiopods which apparently had disappeared far below. The rock has the appearance of typical Trenton. The next shale above abounds again in heads of *Triarthrus.*

The 81st bed of shale proved to be rich in *Triarthrus*, *Lingula*, *Schizocrania*, and *Leperditia.*

The 87th bed abounds in heads of *Triarthrus* and rhabdosomes of *Diplograptus pristis.* A few entire colonies of the same graptolite and young and old specimens of *Conularia gracilis* occur. Bearing, due east.

The 90th bed is full of shells of *Lingula* and *Leperditia* arranged in long drift-lines, the latter running due east.

The 92d bed of shales exhibits 19 surfaces, all covered with *Diplograptus pristis.* These fossils are arranged in a due east direction on all surfaces, except three, which gave the readings N. 70 degrees E., N. 70 degrees E., N. 65 degrees E.

The alternation of shales with Utica slate fossils and more or less calcareous barren banks continues upward. That the shaly intercalations also reach farther down into the Trenton than it might appear from the exposure at the "Flat falls" becomes obvious in the quarry at Ingram's mill, from which N. H. Darton* reports eight feet of limestone with shaly intercalations, on top of the exposed series of rocks.

The conclusions which can be drawn from the observation of this alternation of shales and calcareous layers in the lowest Utica shale is that there were, for a long time, changing conditions which caused the water in this region to be alternatingly clear and then again turbid and moving. It seems also that the appearance of the turbid, moving water exterminated gradually the clear water fauna of the Trenton and introduced new forms, more adapted to the muddy flow.

A similar series of successive shaly and calcareous beds was observed by the writer above Harris' quarry which is near *Middleville on the West Canada creek.* The series, though not so well exposed as the above described one shows at least the occurrence of *Diplograptus pristis* in the shaly intercalations of the upper Trenton.

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*Rep. of the State Geol., 1893, p. 422.

The rhabdosomes pointed in one layer N. 55-65 degrees E.; in another in directions in the neighborhood of N. 65 degrees E.

A small outcrop about a mile north of Dolgeville deserves to be mentioned because the outcropping shale belongs to a higher horizon, in which the limestone intercalations of the lower Utica shale are absent.

On top there are found numerous layers with *Diplograptus pristis*. The fossils are excellently parallel and lie in N. 65 degrees E. direction.

Several layers with mud-flow structure occur below. The latter consists here in the presence of elliptical projections with a system of cresent-shaped, transverse wrinkles on the eastern end. The whole indicates a flow of water from N. 85 degrees E.

A layer with trilobite fragments. Bearing, N. 60-70 degrees E.

A layer with *Diplograptus pristis*. Bearing, N. 60-70 degrees E.

Eight layers densely covered with parallel fragments, especially pleura of *Triarthrus*. Bearing N. 60 degrees E.

Layer with *Diplograptus pristis*. Bearing, due east.

Layer with trilobite fragments. Bearing, N. 48 degrees E.

Layer with *Diplograptus pristis*. Bearing, N. 50 degrees E.

The average of the readings taken in this exposure is N. 63 degrees E.

After the above described observations and others had shown that throughout the series of shales observable in the neighborhood of Dolgeville, there are indications of a constant E. N. E.-W. S.W. flow of the water which deposited the shale, the writer extended his observations to other localities of Utica shale in this part of the state, occasionally also visiting the well known strata outcrops of Hudson River shale at Schodack landing, Norman's kill, Cohoes and Waterford. None of the latter, however, were able to furnish any indications of a motion of the depositing water, on account of the highly folded condition of the rocks.

One exposure of Hudson River rocks deserves mention, that is at *Shear's Blue-stone Quarry near Schenectady*, where some interesting indications as to the water-flow in the Hudson River epoch could be obtained. Between the heavy banks of blue stone, intercalations of a black shining shale occur, which are characterised by a very distinct mud-flow structure. Whitfield* described the same as follows: "One peculiar feature * * * is the appearance as of flowing mud suddenly fixed and hardened on the harder layers, the old depression between the folds being filled with fine mud shale partings, upon which the layers separate with clean surfaces."

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*Wheeler Exp. West of the 100th Mer., iv. Pt. 1. Pal; p. 19.

In one part of the quarry the flow structure indicated a flow from due north on top, and one from N. 15 degrees in the next deeper intercalation. Huge ripple marks, running N. 28 degrees W. and in the next underlying bank N. 25 degrees W., appear there. A deeper shale exhibited again a distinct flow structure with the flow coming from N. 25 degrees E.

Another intercalation contained a small form of *Diplograptus* (cf. *marcidus* Hall), the rhabdosomes of which were generally arranged in N. 10 degrees E., and in another intercalation in N. 16 degrees E., while the underlying bank was marked by wide parallel rills, probably ripple marks, running N. 10 degrees W. At the bottom of that part of the quarry, ripple marks running N. 45 degrees E., appear again.

In another part of the quarry, flow structure could be observed in two succeeding intercalations, running due north and N. 28 degrees E.

Though the composition of the rocks and the ripple marks indicate that these strata were deposited in shallow water and that therefore the conditions since the deposition of the Utica shale had changed, it seems as if there was still a prevailing motion of water coming from a little east of north (average N. 13 degrees E.) or from the site of the Lake Champlain valley.

The next locality visited by the writer was the *Schoharie Kill* near *Fort Hunter.*

A large boulder of black shale, full of siculae and other stages of growth of *Diplograptus pristis* was found in the river bed. The fossils pointed in all directions, as they mostly do, where the young are found. At the base of the outcrop of Utica shale on the right bank near Diemendorf's farm, a layer is exposed which contains *Climacograptus typicalis* and fragments of a bryozoan. Both kinds of fossils are arranged in N. 55 degrees E. direction. The superjacent layer showed the same fossils arranged between N. 30 degrees E. and N. 60 degrees E., while the graptolites in the following layers, some of which were rich in specimens of *Climacograptus typicalis*, showed no arrangement.

The average of the few indications of a directing force is N. 50 degrees E.

The next large outcrop of Utica shale in the Mohawk valley was found in the *Flat creek, near Sprakers.*

In following the gulf one passes at first over Trenton limestone. The boundary between the Trenton and Utica terranes is not well exposed. The first layer with *Diplograptus pristis* shows a distinct N. 70 degrees E. direction in the fossils, the next a N. 60 degrees E. direction.

Farther up appear shales with *Diplograptus pristis*, arranged in a N. 80 degrees E. direction.

Another exposed layer showed the same fossils arranged in two directions, viz: N. 80 degrees E., and S. 80 degrees east, indicating a change of 20 degrees in the direction of the flow.

Then a series of 19 layers was observed, which were densely covered with graptolites. The general bearing was N. 80 degrees E.

Near the falls two layers were found to be striated with specimens of *Diplograptus pristis* in a due west direction, and above the falls two layers with the same fossils, pointing S. 80 degrees E.

Farther up the writer met with layers containing rhabdosomes of *Climacograptus typicalis* arranged in a N. 50 degrees E. direction, and a flow structure, indicating a flow from N. 80 degrees E.

The average bearing of the graptolites along the Flat creek is N. 80 degrees E.

In the beautiful gulf of the *Canajoharie creek* one passes at first over Trenton limestone with wide and huge ripple-marks. In the shale, many long parallel drift-lines of fossils, one of which measured over seven feet, were first noticed. The direction of the drift-lines indicates a flow from due east.

Farther up a layer with numerous specimens of *Climacograptus typicalis* in a N. 80 degrees E. direction appeared, then drift-lines of trilobite fragments, brachiopod shells, etc., indicating a flow from N. 50 degrees E., overlaid by layers with flow structure towards due west.

Then two layers striated with *Climacograptus*, bearing N. 80 degrees E., and two layers with the same fossils in N. 70 degrees E. direction.

Farther up only one more layer with graptolites came to notice and the fossils in it showed no arrangement at all.

The average direction of the fossils is also here, as at Spraker's, N. 80 degrees east.

In the bed of the *Otsquago creek*, near *Fort Plain*, below the old cheese factory, layers of Utica shale were found, with specimens of *Climacograptus* and *Endoceras*, the bearing being N. 50-80 degrees E.

In a small exposure, on the right bank, above the factory, layers full of *Diplograptus pristis* were found. The graptolites were mostly deposited in drift lines about one foot long and indicate a flow from N. 70 degrees E.

Farther up, in the bed of the creek, widely exposed, layers were observed which are densely covered with rhabdosomes of *Diplograptus pristis* hardly varying from N. 60 degrees E., while another layer above showed no general direction, but had quite a number of rhabdosomes directed toward the southeast.

A remarkable series of layers was found below the mouth of the Oxtungo creek. The layers are completely covered and striated by parallel rhabdosomes of *Diplograptus pristis*, which point in the successive layers: N. 60 degrees E., due N.. due E., N. 40 degrees E., N. 60 degrees E.,then a layer with *Climacograptus bicornis* in different growth stages and no direction followed. The surprising angle of 90 degrees between two layers, only a few inches apart and the change in the fossils indicate the very slow manner of deposition of this material. It seems also that the changes in the direction of the flowing water caused the separation into the thin layers. The average of the directions, on account of the abnormal northern direction, on one layer, is only N. 63 degrees E.

On *Oxtungo creek*, a layer with *Endoceras* shells, which pointed with the apices to N. 70-80 degrees E., was found. It was covered by a layer with excellently preserved specimens of *Climacograptus bicornis* in a N. 70 degrees E. direction, while a few superjacent layers, which were sufficiently exposed, and contained specimens of *Climacograptus bicornis* and a few young of *Conularia gracilis*, showed no arrangement.

On *Fulmer creek*, near *Mohawk* shales were found containing *Climacograptus typicalis*, which pointed to N. 50-60 degrees E., then *due north*, then N. 80 degrees E. (only the majority of the rhabdosomes, and many exceptions), then N. 85 degrees E., then a layer with rhabdosomes of *Diplograptus pristis* in a general N. 80 degrees E. direction was found; then again a layer with *Climacograptus typicalis*; the fossils were arranged in a N. 40-80 degrees E. direction.

Farther up, several other small exposures with *Climacograptus typicalis* were observed which did not show any arrangement.

The average of the readings is in the neighborhood of N. 70 degrees E.

In the *Deerfield ravine* (Real's creek) north of *Utica*, the writer found Utica shale rich in specimens of *Climacograptus typicalis* which gave the following readings in the layers met in following up the creek: S. 80 degrees E. (many exceptions), N. 80 degrees E., S. 65 degrees E., S. 70 degrees E., S. 65 degrees E., N. 40 degrees E., S. 85 degrees E., then a layer with colonies of *Climacograptus typicalis* and no direction, then a general arrangement to S. 65 degrees E. and to N. 60-80 degrees E.

At another exposure farther up the creek, the basal layers showed no direction, after which followed a layer with S. 60 degrees E., then two layers with a few colonies and detached rhabdosomes, the latter pointing to S. 65 degrees E., then a layer with graptolites distinctly arranged in S. 60 degrees E. and finally one exhibiting a N. 80 degrees E. direction.

In a third exposure many layers were measured which exhibited the numerous specimens of *Climacograptus typicalis* in directions ranging from N. 80 degrees E. to S. 50 degrees E.

The characteristic features of the exposures near Deerfield are that, 1st—the fossils are not so strictly parallel as in the middle part of the Mohawk valley, that the directing force, therefore, apparently was weaker, 2d—that the general direction is not, as in the other exposures, somewhat north of east, but a little (about 10 degrees) south of east.

Other exposures of lower Utica shale were found along "*Nine Mile creek*" from South Trenton to Holland Patent. In a small exposure in the village of South Trenton, some layers covered with parallel rhabdosomes of *Climacograptus typicalis* were observed, which gave the following readings: N. 80 degrees E., N. 60 degrees E., S. 79 degrees E.

Below the village, the directions in successive layers were: N. 60 degrees E., N. 70 degrees E., N. 40 degrees E., and a little farther down a layer with N. 75 degrees E. was observed.

In an exposure near Holland Patent, extending down to the Trenton limestone, shale with distinct drift lines of fragments of fossils in N. 76 degrees E. direction, was observed, underlying a layer with graptolites in a N. 70 degrees E. direction; the latter again being overlain by layers with graptolites pointing to directions between N. 60 degrees E. and N. 70 degrees E.

The interesting fact which appears in the readings from Nine Mile creek is that, though the exposures are farther north than all the other localities visited and even north of the southern border of the Archæan region of the Adirondacks, yet the flow that arranged the fossils must have come from about N. 70 degrees E. which is the average of the readings.

In *Lee's Gulf near Turin* (Black River region west of the Adirondacks) lower Utica shale appears not far above the Trenton. Only specimens of *Endoceras* were found besides the heads of *Triarthrus*, the former showing no direction. Boulders in the gulf were found to be rich in specimens of *Climacograptus typicalis*, which also failed to show any arrangement at all.

In the *Turin Gulf* (along the road to Welsh hill) in the first exposure a layer with *Climacograptus typicalis* and *Thamnograptus*, and several layers with specimens of *Endoceras* were found, none of the fossils of which showed indications of arrangement.

In a small quarry farther up the gulf, numerous layers containing *Climacograptus typicalis* were found. None, except one in which the majority of the fossils were arranged in a N. 10-20 degrees E. direction, showed any arrangement.

In a third exposure the graptolites were irregularly distributed in all layers.

In a fourth quarry no fossils, but a layer with a mud-flow structure was found, indicating a motion of the water from N. 12 degrees E. in the Black River region.

The two localities which the writer had an opportunity to see, gave no indications of the presence of a constant flow of water in the lower Utica shale epoch. The two layers with indications of arrangement are opposed by too many layers without any arrangement of the fossil to indicate more than an occasional southerly flow of the water.

General Conclusions.

The following conclusions can be drawn from the preceding observations:

1. There existed, at the time of the deposition of the lower Utica shale, a general and constant flow of water from the average direction N. 78° E., in the region south of the Adirondacks, while this flow does not seem to have been present west of this ancient land area.

The averages of the readings in the visited localities are:

(Schenectady)	(N. 13 degrees E.)	(Hudson R.)
Spraker's	N. 80 degrees E.	
Canajoharie	N. 80 degrees E.	
Osquago-Oxtungo creek	N. 65 degrees E.	
Dolgeville	N. 70 degrees E.	
Mohawk	N. 72 degrees E.	
Deerfield	S. 80 degrees E.	
Nine Mile creek	N. 70 degrees E.	
Turin	0 degrees.	

The total average of the readings (excepting those of Schenectady and Turin) is N. 78° E.*

That the flow came from N. 78° E. and ran toward S. 78° W., can be inferred from the appearance of the mud-flow structure, the drift-ridges behind the fossils (*Endoceras*), the eastward pointing of the apices of the *Endoceras* shells, and often also of the sicular ends of the graptolites. From the common occurrence of drift lines of longitudinally arranged fossil fragments and of smaller shells of *Endoceras*, behind the apertures of larger shells of *Endoceras*, it becomes apparent that the apices of these shells would generally point towards the slowly flowing water. As now the apices of the shells of *Endoceras* mostly point eastward, the water must be supposed to have come from the east. In layers containing specimens of *Endoceras* and graptolites together, the sicular ends of the latter have been observed to point in the same direction as the apices of the *Endoceras*, hence the general eastward pointing of these sicular ends in the layers without any shells of *Endoceras*, or mud-flow and drift-lines may also be regarded as indicating a flow from the east (or more exactly north of east). Gasteropods have been noticed with transversally arranged fragments which apparently were arrested by the immovable shell, on the east side, and with a drift-ridge of longitudinally arranged fragments on the west side.

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*Compare the accompanying chart (plate XXII) which shows the average directions of the flow at the different localities.

2. The motion of the water brought about, in this district, the changes in the sedimentation and in the fauna which constitute the differences between the Trenton and Utica terranes. This assertion is principally based on the following observations:

a. The approach from the Trenton limestone to the Utica shale, as well as the lower Utica shale itself are, as described before, from the East Canada creek near Dolgeville, marked by a regular alternation of beds of limestone and shale, the shaly intercalations at first being far apart and thin, but increasing steadily until the limestone bands dwindle into insignificant intercalations and disappear at last entirely. This gradual change has already been observed by Vanuxem* on the West Canada creek, near Herkimer, and also north of Little Falls. It is also observable in the localities south of the Mohawk river, where Hall† described *Sphenothallus angustifolius* as being found in the shaly upper Trenton limestone, near Canajoharie. Walcott‡ reports from the town of Deerfield that "the Trenton and Utica formations are intimately connected lithologically." Prosser§ found sixty feet of passage beds, consisting of shale and limestone beds in a well at Chittenango, which is south of lake Oneida and west of Utica.

b. Further, as already observed by Vanuxem and verified by Hall‖ the Trenton limestone and the Utica shale are in the state coëxtensive and concordant. "The whole of the Utica rests upon the Trenton and upon no other rock." (Vanuxem). Changes in the depth of the water can not, therefore be adduced to account for the change in the composition of the sediment.

c. The change in the fauna is gradual, as shown by the section near the Flat falls on East Canada creek and gives the impression that part of the Trenton fauna, especially the corals, were unable to continue to live in the mud-bringing, moving water and gave place to other forms thriving under the new condition.

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*L. Vanuxem, Nat. Hist. of N. Y., pt. III, 1842, p. 58.

†J. Hall, Pal. of New York, vol. I, p. 261.

‡C. D. Walcott, The Utica slate, etc., Trans. Albany Inst., vol. X, pp. 1–17.

§Ch. S. Prosser, Bull. of Geol. Soc. of Am., vol. IV, p. 91.

‖Proc. Am. Asso. Adv. Sci. 1878, pp. 259-265.

The differences between the Trenton and Utica formations, as established in New York state, are not local or prevailingly lithological. This fact, as well as others valuable to the understanding of the nature of the motion of the water are excellently presented in the papers of Walcott on the Utica slate.* That author states that from lake Huron, across the province of Ontario to New York state and thence by way of the Black river, Mohawk, Hudson, lake Champlain, St. Lawrence valley to Anticosti and from the valley of the Hudson to Virginia the differences between the Trenton and Utica formations are essentially the same. The black bituminous shale forms a distinct horizon above the Trenton. Thus it becomes apparent that the change in the physical conditions which inaugurated the Utica epoch in the Mohawk region extended over a wide area, along the southern and eastern coast of the then existing land and over the site of the present Appalachian mountain system.

It must be added that the alternations of limestone beds and shales in the upper Trenton and lower Utica shale are also widely extended. Cushing† expressly mentions the shaly intercalations in the Trenton limestone on the shores of lakes George and Champlain while the Geology of Canada‡ reports that "the limestones of the Trenton formation are generally separated by thin layers of black or blackish brown bituminous shale. The layers in some places become thicker towards the top and present a passage to the succeeding deposit," the Utica shale.§

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*C. D. Walcott: The Utica slate and related Formations; cf. above. C. D. Walcott: The Value of the Term—Hudson River Group. Bull. of Geol. Soc. of Am., vol. 1, pp. 335-356.

†Rep. of the State Geologist for 1893, p. 483-486.

‡Geology of Canada, p. 198, 1863.

§Walcott reports that there are no limestone intercalations in the 180 feet of Utica shale, measured by him in Jefferson county, (east of lake Ontario). A like observation has been made by the writer near by, in Lewis county. As there, however, the shaly intercalations of the upper Trenton are quite conspicuous it seems essentially a question as to the drawing of the line of separation and it is possible that there the Trenton conditions continued a little longer and terminated more suddenly. The reappearance of a Trenton-like bed in the series of passage beds on East Canada creek is certainly indicative of such a possibility.

The general occurrence of the passage beds gives evidence that the change from the physical conditions of the Trenton epoch to those of the Utica epoch was not a sudden one, but consisted in a transition by numerous oscillations. But after the conditions favorable to the deposition of the Utica shale had once gained prevalence, they must have continued for a long time. This can be inferred from the extensive geographical distribution of the Utica slate and its retaining its characteristic black carbonaceous slaty character, which shows the rock to be a slow deposit of deeper water, and from the comparatively large volume, notwithstanding its probably slow deposition.

Walcott further develops the important fact that, while all along the coast of the old continent the Utica shale was formed, the formation of limestone continued towards the center of the Appalachian basin.* That author shows that the same change which terminated the Trenton formation in the east and north of the Appalachian basin, and inaugurated the Utica epoch, also wrought some change in the fauna of the limestone-forming sea in the center; a change which is recognized in the difference between the faunas of the Trenton and the superjacent Galena limestones. While the Utica shale has fifty-four species limited to its boundaries, and thirty-six derived from the Trenton, the Galena limestone has only nineteen species peculiar to it, and fifty-six passing up from the Trenton formation beneath. "This diversity is undoubtedly owing to the greater variation in the character of the sediments of the Utica slate as compared with the Galena, when the change from the Trenton limestone-forming deposit occurred." While this diversity, on the one hand, proves that a change in the physical conditions in the east and north must have changed the fauna there, it demonstrates also, on the other hand, that this same physical change made its influence felt even in the center where the limestone formation continued.

While Walcott, on the evidence of Prof. Orton's report on the geology of Ohio (1880), shows that the Utica shale is still met with in wells drilled in northwestern Ohio, but is reduced and altered as it approaches the Ohio valley, and is finally lost, it becomes also apparent that the cotemporary Galena limestone has been found as far northeast as on the Escanaba river in the peninsula of Michigan (Hall), but going northward also, it becomes reduced and interstratified with shales. Chamberlin (Geology of Wisconsin, vol. II) reports a similar change in the Galena limestone towards the northwestern portion of Wisconsin. The modification consists mainly in the introduction of more clayey material in the form of shaly leaves and partings. The change is gradual and progressive from forty to fifty miles.

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*This term includes the interior continental basin from the Appalachian system to the Mississippi. Later the Galena has been referred to the Trenton of New York state by several geologists, viz., N. H. Winchell, E. O. Ulrich and F. W. Sardeson, vol. III, part II, Final Report Minn. Survey, 1896.

The statement that in Iowa, Wisconsin and Minnesota the Trenton limestone has been found to pass into the Galena by slow stages proves that, exactly as in the east, the change was not a sudden but an oscillatory one.

From the distribution of the Galena limestone in the northwest, and especially from its occurrence on the Escanaba river, it seems that this limestone facies of the Utica shale approaches the coast in the northwest much more than it does in the east. This observation, together with the reported thinning out* and final disappearance of the Utica shale towards the northwest along the Archæan area, and with the remarkably wide extension of the Utica shale through Ohio and to Kentucky—where the lower part of the Cincinnati shale by the presence of Utica graptolites and *Triarthrus becki* is still characterized as a deposit of the Utica epoch—are of significance in regard to the nature of the change, for they indicate a farther transference of the mud in the direction of the motion of the water in the Mohawk region, than towards the northwest.

It has so far been demonstrated that in the region south of the Adirondacks, the close of the Trenton and the beginning of the Utica epochs evidently stood in causal connection with the coming in of a sediment-bringing west southwest current, and not with changes in the sea level. It has further been shown that the change from the Trenton to the Utica formation took place throughout the north and east of the Appalachian basin where the shale overlies the limestone, and also somewhat modified, in the center of the basin where the Galena limestone represents the Utica epoch. The change to Utica shale and Galena limestone was not a sudden but a gradual one, by a series of passage beds, and the Utica shale has been shown to extend farther away from the old coastline in a south-westerly direction than towards the northwest, in which latter direction it diminishes remarkably in volume.

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*On Manitoulin island the Utica shale has a thicknes of only 50 feet.

The direct conclusion, which one might be inclined to draw from the foregoing statements, is that the current observed in the Mohawk region is responsible for all these phenomena. But a comparison of the relatively small area over which the influence of the motion of the water has been proved, with the immense area involved in that general conclusion, will at once demonstrate the great disproportion between the studied area and the conclusion, and will prove the necessity of completing the work by studying the outcrops of Utica shale in the Appalachian region, in the lake Champlain valley—which on account of its lying in the direct line of water-motion, observed in the Mohawk region, is especially important—in the Canadian basin, and in the northwest. The writer hopes to have an opportunity to do this work next summer.

Meanwhile it may be allowable to discuss the character of the oceanic motion observed in the Mohawk valley under the supposition that it was part of a more extensive marine current which brought about the widely extended change from the Trenton to the Utica epoch.

The motion of the water could have consisted in coastal tidal currents, in wind-drifts, or it could have been part of the general oceanic circulation.

It is obvious that the receding and advancing tide alone could not have produced a motion apparently in only one direction and parallel to the coast, as the motion south of the Adirondacks must be supposed to have been. Powerful tidal currents sweep along many shores. They are best known from the straits around Great Britain and from Long Island sound, but they occur as real currents only in straits, while along open shores the translation action of the tide is only small. The Ordovician sea, which was at the present site of the Mohawk valley, was, however, open towards south and therefore affords no reason for assuming the presence of a strong tidal current.

A constant and only slightly changing current produces an even bedding in the deposits, while beneath strong tidal currents, owing to the strong flow during the incoming tide and its alternation with high-water and low-water quiet, in the ebbing tide, layers that are obliquely laminated alternate with ordinary layers. The Utica shales and slates in this neighborhood are remarkably even-bedded and there are no traces of cross bedding noticeable.* It is possible that the lack of oblique lamination in the Utica shale is due to the greater depth in which that sediment was deposited, but then it would seem strange that an inconstant and irregular tidal current near the coast should have resulted in a constant, apparently regular current in water of a greater depth such as that depositing the Utica shale most probably was. Tidal currents further are, however strong they may become in certain places, only local phenomena; their influence extends neither far into the open sea nor into the oceanic depths. The uniform lithological and faunistic character and wide extension of the Utica shale, however, show that it cannot be the result of local and irregular physical agents. Moreover, the fine grain, even bedding, and rich admixture of carbonaceous matter indicate that the shale is the result of a very slow and equal deposition, such as generally takes place only in the deepest part of the littoral region. It is the concurrent opinion of geologists that the graptolite shales and slates, in general are slow, deep-water deposits. This opinion is founded on the wide horizontal and small vertical distribution of the graptolites and graptolite shales. Hall has already reached this conclusion in his exhaustive study of the Quebec graptolites.

A glance at the accompanying map will show that the shale in the localities where the parallel arrangement of the fossils has been observed, must have been deposited in considerable depths, for the outliers of Utica shale at Wellstown on the Sacondaga river and on the west shore of lake George, as well as the direction of the fossils as far north as Nine Mile creek, leave no doubt that the coast-line of the sea of the Utica epoch must have been considerably farther north than the present extension of the Utica shale as surface rock would indicate. For the shale near Dolgeville, twenty miles can be regarded as the minimal distance from the coast-line. The measurements of the dip in the Mohawk river valley are unreliable on account of several faults in the rocks, they would point to an angle of several degrees, which would mean an unusual "steep incline," for an angle of about three degrees gives a descent of one mile in twenty miles, which is a comparatively rare occurrence in modern seas. Williams* obtained some exact figures in central New York. He found in Cortland county a descent of fifty-six feet per mile. As the dip increases a little towards east, sixty feet per mile can be regarded as a minimal value, on account of the greater approach of the strata to the coast line in Herkimer county. These two data, twenty miles distance and a descent of sixty feet per mile, however, would give a depth of 1200 for the sea in the Mohawk region. It must, therefore, be concluded that the depth, in which the Utica shale, showing the arrangement of the fossils, has been deposited, was considerable. It agrees with this, that the preservation of the delicate rhabdosomes of the graptolites points to a very gentle motion of the water, which, in most cases did not so much transport the organic relics, as arrange them. It is especially this gentle, but constant, deep-reaching action of the moving water, which, to the writer, seems not to be quite in accordance with the influence to be expected from a tidal current, but rather with that of a branch of the general oceanic circulation. The apparent independence of the current from the coast, which is indicated by the distant transference of mud towards the Ohio river and by the approach of the Galena limestone to the coast in the northwest, also seems not to indicate the action of a tidal current.

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*Oblique striation in the Trenton limestone has been observed east of the Hudson (cf. Report of State Geologist for 1893, p. 428) which is of interest as it probably points to the presence of shallower water in that region during the Trenton epoch and, as during the Trenton and Utica epochs the sea stood at the same level, also to a shallow region in the Utica epoch.

Finally, it is very doubtful, whether a tidal current would have been able to influence the fauna of the entire Appalachian basin in such a degree, as is indicated by the difference between the faunas of the Trenton and Galena limestones. The constant deep-reaching and equally directed character of the water motion also excludes its having consisted of local wind-drifts.

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*Dip in Central New York. Am. J. of Science, vol. 26, p. 303.

These considerations have induced the writer to see in the observed movement of the water, a part of the general oceanic circulation and to suppose the passing of an E. N. E.-W. S. W. current along the southern coast of the Adirondack land-area. It is probable that the obstacle offered by this projecting land decreased the depth of the current and made thus the phenomenon of the arrangement of the fossils especially visible in the Mohawk river region. As the transporting power of the currents has been found to extend to a depth of 300 fathoms, there can be no doubt that the influence of the supposed current could have reached to the depth in which the graptolite-shale of the Utica epoch was deposited.

It might seem unreasonable to speak of a strong, deep-reaching current action in an age, in which the distribution of the fossils generally has been regarded as proving the absence of all diversity of climate and of oceanic temperature.* But, accepting the first of the two rival theories as to the cause of the oceanic circulation, namely, that which claims that the latter arises entirely from differences of temperature and salinity, it will be easily seen, that the latter again are due to differences in the insolation on the surface of the ocean. But the insolation must always have been different at different latitudes, and this unequal distribution of solar heat must always have disturbed the equilibrium of the spheres and hence must have constantly produced currents to restore the equilibrium. Accepting the other view, that oceanic currents are caused by the atmospheric circulation, would be only inserting a new link into the chain of conclusions, as the circulation of the air itself is due to unequal insolation.

Investigators like Dana, therefore, have always regarded the existence of a system of oceanic circulation, similar to the present, even in Palæozoic times, as self-evident. Dana† for instance, in discussing the presence of the Trenton limestone over the whole breadth of the continent, seeks an explanation in the theory, that, "the currents of the ocean which ordinarily swept over the land (the Labrador current from the north, along the eastern border, and the Gulf stream from the south, over the interior), must have had their action partly suspended." This view not only includes the assumption that current-action terminated the Trenton epoch, but it suggests also that the current observed in the Utica shale of the Mohawk region was part of the Labrador current. It came from north but under the influence of the diurnal rotation had a tendency to deviate in a westerly direction on account of which tendency it pressed toward the east border of the then-existing land, crossed the region of comparatively shallow waters, which is supposed to have foreshadowed, during the Ordovician era, those ranges which arose at the end of that era—namely the Green mountains and parts of the Appalachian system—and entered the continental basin in eastern New York as a W. S. W. current. Dana says regarding this shallow region (op. cit. p. 211): "Along its course, there were Archæan islands and reefs, when the Silurian era opened,—portions of the Blue Ridge to the south, the Highlands of New Jersey and Orange and Putnam counties, N. Y., and the patches of Archæan rocks in New England being some of these areas. It was hence a barrier region to the continent, over which the Atlantic currents flowed and waves broke; and here, therefore, fragmental rocks—rocks of sand. pebbles, mud and clay—ought to have abounded." Investigations of the present currents have shown, that, on account of the increased velocity in the straits of an archipelago, the finer partly suspended silt, such as evidently formed most of the Utica shale, is carried farther away, while in the straits themselves, former deposits may be swept off the floor of the sea. The Gulf stream has been found not to drop any deposits in its direct course in the strait of Florida, while its lower part from the exit at Florida, where the current rapidly decreases in velocity, to cape Hatteras has been compared to a muddy river. Places where "hard bottom" has been met with on account of the scouring action of the currents, have been found in various places and often in considerable depths, especially between submarine ridges and islands; between the

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*Barrande has distinguished two bands in the Cambrian of Europe which are thought to represent climatic zones.

†James D. Dana; Manual of Geology, 3rd ed., p. 208.

Canary islands for instance, in a depth of 6,000 feet.* Similar conditions must have prevailed in the eastern border region; hence the absence of the typical Utica shale and its fauna in eastern New York and the region east of the latter,† its fast increase in volume towards west,‡ from where the material could not have come. At Glens Falls the velocity was still too great to allow the deposition of the fine detritus; but in entering the wide continental sea, the current rapidly decreased in velocity and consequently the increase in the thickness of the deposits until the maximum of sedimentation seems to be reached at the present site of Utica, where also the obstruction to the current from the projecting Adirondack land is removed and the waters, being allowed to spread a little towards the north (the readings obtained at Deerfield seem here to be significant), a somewhat abrupt decrease in the velocity of the current must have occurred. This, however, must necessarily have resulted in a sudden increase of the quantity of sediment. As the current now, on its W. S. W. progress left all shores behind, it received no new supply of terrigenous sediment, hence, the rapid decrease again to the west of Utica, as indicated by the measurements obtained in drilling wells in the western part of the state. In a well at Chittennago, south of Oneida lake, only 200 feet of Utica shale have been met with. But then, this decreased Utica shale extends over a wide area, as far as the Ohio river, in the direction of the observed current, while it thins out towards the north and northwest, where the Galena limestone formed at the same time. In those regions to which the current could not carry its silt. the difference in temperature and salinity which necessarily must have existed between the current water and the quiet Trenton sea, were sufficient to produce a change in the fauna, though the limestone formation did not cease. These differences may have been only slight, for the fauna of the deeper littoral zones, in which the limestones probably formed, is known to be very sensitive to such differences.

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*T. M. Reade, Phil. Mag. vol. xxv, p. 392.

†Walcott states that the fauna of the upper part alone of the Utica formation occurs within the valley of the Hudson.

‡Dana (op. cit. p. 196) gives only 15 to 35 feet at Glens falls, while in Montgomery county it is 250 feet and near Utica amounts to 710 feet.

The cause of the extension of the Trenton limestone all over the continent, even over the eastern border region, has been sought in the existence of a "barrier region outside of the limestone area, near or outside of the present Atlantic coast line."* Billings† also explains the prevention of British specimens from being introduced into the Trenton sea by the presence of this eastern coast barrier; which latter dipped down beneath the ocean in the following period and allowed the incursion of British species, which he observed. Geologists, in general, have resorted to the assumption of the former existence of this land in order to account for the enormous accumulation of sediments in the Appalachian region, during the Paleozoic age. The writer sees in the observation of the arranged fossils a new argument in favor of this theory, for the direction from which the current comes must also implicitly indicate where, in the preceding Trenton period the barrier was, that closed the Appalachian basin towards the Atlantic ocean. As the transition from the Trenton limestone to the Utica shale in the east, and to the Galena limestone in the west, takes place only gradually, by a hundredfold alternation of the relative rocks, it must be concluded that there has been a long period of oscillations of the barrière, these oscillations alternatingly closing and opening the continental basin to the Atlantic current in the northeast.

As the limestone continued to form in Anticosti during the Hudson River epoch (including the Utica shale) and only thin beds of shale are reported to occur in the series, it is possible that this region already lay outside of the shallow sea and of the archipelago which Dana supposes to have occupied the site of the present Appalachian region and Green mountain system, and which, under the wearing action of the sea waves must be supposed to have furnished part of the fine mud consolidated into the Utica slate and shale.

Towards the end of the Hudson period, the uplift of the Green mountains and the emergence of the Appalachian folds probably turned the Labrador current again into the Atlantic ocean.

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*Dana, *op. cit.*, p. 208.

†Cf. Dana, *op. cit.*, p. 250.

LAKE ADIRONDACK.

By B. F. Taylor, Fort Wayne, Ind.

Early in October, 1893, I joined professor J. W. Spencer for a reconnoissance of the slopes of the northeastern portion of the Adirondack mountains. The trip was made on Prof. Spencer's invitation, and his lead was followed. Our efforts were directed toward a search for evidences of Pleistocene submergence, and more especially to an attempt to trace the Iroquois beach at high levels.

The Iroquois beach had been traced by Mr. G. K. Gilbert along the south side of lake Ontario and northward along the east side to cape Rutland, about four miles northeast of Watertown, several years before.* To this point the beach is a prominent feature, easily traced, but the character of the country changes here to one of rocky knobs, largely bare and with sandy wastes between. Gilbert and Spencer both made repeated efforts separately, and once jointly, to carry the tracing farther, but without much success. Mr. Upham also entered the field with Mr. Gilbert. As a result of his several excursions Prof. Spencer believed that he had traced the Iroquois beach in somewhat modified form past Carthage, Natural Bridge, Harrisville, East Pitcairn, Fine, Clarkesboro, and South Colton.† Just before we met he had taken up the line again at South Colton and carried it farther northeast past Parishville and Dickinson Center and on the south to a point on Salmon river near Owl's Head station about ten miles south of Malone.

It is not the object of this paper to go into details of the observations made except in two or three instances. A few general statements of results will suffice. Terraces were seen in the distance near Standish, on Upper Chateaugay lake, but their character remained a matter of doubt. Terraces, mostly rather faint and poorly formed, were also seen around Chazy lake. These suggest the presence formerly of static waters in these basins at higher levels than now but nothing indicating wave action was seen.

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*"The History of Niagara River." In the Ann. Rept. Commissioners of State Reserv. of Niagara, 1889. Also in Rept. of Smithsonian Institution for 1890.

†"The Iroquois Shore North of the Adirondacks," Bull. G. S. A., vol. 3, 1891, pp. 488-495, including discussion by Mr. Gilbert.

The writer also made an attempt to trace this beach northeastward from Watertown, early in November, 1893, but with only limited success. It seemed to be traceable in one form or another along the line indicated by Prof. Spencer to the vicinity of East Pitcairn. But it passes thence to the north by South Edwards and Edwards. Littoral features doubtfully referred to this beach were followed still farther north from Edwards to Russell and thence northeast to Colton.

Passing over to the Saranac valley at High falls, above Moffittville, terraces were found at about 1025 and 1100 feet and others at higher levels half a mile northwest of Moffittville. None of these, however, were as distinct and finely formed as two terraces that were found higher up the valley on the north side on the farm of Mr. Wilcox, about a mile and a half west of Redford. Here, about forty rods back from the road, are two flat-topped terraces each with a distinct bluff front, the upper about twenty-five feet above the lower. The upper one extends a considerable distance back to the northwest to a small stream.

These two terraces are part of an old delta of a creek that comes down from a high mountain about three miles to the northwest. Standing on the upper terrace we saw a distinct bench around the valley on the other side, at about the same level. Towards the southwest, and less noticeably towards the south and northeast also, this bench was discernible. The altitude of the upper terrace is approximately 1,370 feet (aneroid from Dannemora). Nothing marking a water margin was seen at a higher level, but a few terraces and deltas were found at lower levels. About a mile east of Dannemora, on the south slope of Rand hill, there is a delta of rounded gravel which is cut by the Chateaugay narrow gauge railroad and excavated for ballast. Its upper level was not measured, but at the pit the top of the bank is about 25 feet high or about 950 feet above tide, while the top of the delta is probably somewhat higher. This delta may correspond with the lower terrace at High falls. In the Au Sable valley northeast of Black Brook we found a few faint terraces up to corresponding hights, but nothing so definite. Only a small part of this valley, however, was examined.

After a little over a week together we separated, Prof. Spencer going south along lake Champlain, while I began a search for beaches, mostly at lower levels, on the northern slope of the mountains. In several favorable places evidence of wave action was looked for on the exposed outer slope, at levels corresponding to the valley terraces, but none was found. Afterward I learned from credible sources that there are sandy terraces in the valley of the east fork of the Au Sable river near Keene, at levels which seem to correspond with those near Redford.

The reconnoissance which we made was not a thorough one and the facts gathered are too few for positive statements. But it seems pretty clear that at least in the Saranac valley there was still water at the level of the Wilcox terraces, and later at that of the High falls and Dannemora terraces. The absence, so far as observed, of any evidence of wave action at these levels, even on the outer exposed slopes, suggests that this body of water was not of great size, but was confined to this valley and perhaps one or two other adjacent valleys separated by cols a little below the terrace level. Apparently the only explanation of such a lake is that it was held up by an ice-dam —by the great glacial tongue that extended southward in the valley of lake Champlain. It is not certain, but seems likely that at its greatest extent this lake included the valleys of both the east and west forks of the Au Sable river. This would give it a quite irregular shape with three expanded parts. For this lake I propose the name lake Adirondack. There was probably no other glacial lake of equal size within the Adirondack area.

The outlet of lake Adirondack was not found, but the Wilcox terraces are close up to the general floor or half-finished peneplain of the Adirondacks. Nearly all the modern lakes in the central area of the mountains lie in basins only slightly depressed below this plain, which is between 1,400 and 1,600 feet in altitude, and the higher mountain peaks stand as monadnocks or clusters of monadnocks upon it.

In one or two seasons after our joint excursions Prof. Spencer carried his explorations into the mountains of New England. He reported his results at the Springfield meeting of the American Association for the Advancement of Science in August, 1895, and claimed to have found evidences on both the north and the south sides of the mountain masses of New England that indicate post-glacial or glacial submergence to at least 2700 feet.* In making his statement Prof. Spencer referred to other similar high level terraces farther west, meaning apparently the terraces which we had seen in the Adirondacks. Having been with Prof. Spencer when he made the Adirondack observations I desire to say that in my opinion nothing we saw there could bear the interpretation which he has given. Not the slightest evidence of wave action was seen—nothing that might not have been made in lakes of small or moderate size ponded by the ice sheet. Nothing was seen that is not better and more easily explained in that way than by the supposition of high marine submergence. Furthermore, the observations which I made on the northern slope after the joint excursion, occupying over three weeks of the fine autumn of that year, enable me to say with some confidence that there is no evidence of wide-spread high level submergence on that slope.

If lake Adirondack was a glacial lake as supposed, then some other interesting conclusions follow. It is a common assumption with some writers on glacial subjects that the Adirondacks continued to be an important center of glacial growth and dispersion for a considerable time after the front of the main ice-sheet had withdrawn from the Ontario basin entirely, and partly or entirely from the Champlain basin. Those who favor the idea of so-called "sedentary" ice-sheets are particularly inclined to this view. But if lake Adirondack existed as supposed, then its very existence is in conflict with such an idea. No doubt there were some more or less important local glaciers among the high peaks of the Adirondacks after the main sheet had uncovered the south, east and west flanks of the mountain mass, but they did not deploy far on the peneplain below and certainly did not constitute anything that could properly be called a local ice-cap like that which Prof. Chamberlin describes as covering the Redcliff peninsula of Greenland. This conclusion is further strengthened by the observations of Prof. C. H. Hitchcock, who recently ascended to within a hundred feet or so of the top of Whiteface mountain (4871 feet altitude) and found its slopes all the way up plentifully strewn with bowlders and fragments of Potsdam sandstone which must have been carried up by the ice from a northward or northeastward quarter.* This seems to indicate that the main ice-sheet overrode the higher peaks at least for a time, and it seems to imply further that there was no considerable amount of vigorous glaciation by local glaciers of notable size or by a local ice-cap, either following the retreat of the main ice-sheet, and probably none preceding its advance. Such facts shed an important and very welcome light upon the climatic conditions that prevailed along the ice-front. They show us that the peripheral belt of ablation on the surface of the ice-sheet must have been at least one hundred miles or more wide, (it may have been even three or four times this width) and hence that the névé line on the ice-sheet itself was well back from the front. For when the reentrant front of the ice-sheet rested against the northeast corner of the Adirondacks at an altitude of 1400 feet or over, the peneplain at 1400 to 1600 feet was distinctly below the snow or névé line.

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* The writer was not present at Springfield, and has gathered the main points of Prof. Spencer's communication from two abstracts. Proc. A. A. A. S., vol. XLIV, p. 139. Also AM. GEOL. for October, 1895, p. 249-50.

WHAT IS THE OLENELLUS FAUNA?

By G. F. MATTHEW, St. John.

ST. JOHN, N. B., 23d March, 1897.

PROF. N. H. WINCHELL,

Dear Sir:—As you have requested me to express in your journal my views as to what the Olenellus fauna is, and what its relation to Paradoxides, I have briefly outlined in the following article the data bearing on this point, known to me. I hope it may stimulate some of the American geologists to seek a solution of the problem that shall be more direct. In the great body of slates existing at lake Champlain and along the valley of the Hudson, with their enclosed limestone bands and lentilles, there must be faunal groups other than have been described, and the means of a better presentation of those already known. A careful search and mapping of exposures where fossils are found, would reveal the structure, and prove or disprove the theory of the mingling of the Paradoxides and Olenellus faunas in the Hudson valley.

Hoping that the following paper may meet your wishes, I remain

Yours sincerely,

G. F. MATTHEW.

In view of the tendency that exists at the present time to refer all pre-paradoxidean faunas to the Olenellus horizon, whether they contain that genus or not,* the present seems an opportune time to inquire how far such a practice is advisable, in view of the wide range that has been given to that fauna by the addition of numerous faunas, mostly pre-paradoxidean in Europe, America, and elsewhere.† It is not known that all these branches of the Olenellus stem preceded Paradoxides, nor is it known that even the type species preceded this genus.

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* Stated by Prof. Hitchcock at Buffalo in August, 1896, in his report to the Geological Society of America on the petrographical excursion in the Adirondacks.

That Olenellus is older than Paradoxides is altogether a matter of inference, based partly upon the constitution of the Olenellus fauna itself, and partly upon the fact that related subgenera are found below Paradoxides. Yet such is the effect of the strong plea that has been made for the greater antiquity of Olenellus, that faunas older than Paradoxides‡ have unhesitatingly been referred to the Olenellus horizon, though no species of Olenellus has been found in them. Why, then, should they be referred to the Olenellus zone?

Let us see if we can gather any information on this still obscure question, the age of Olenellus, from the pre-Paradoxidean faunas. There are two aspects of proof available from the olenellid faunas themselves which may throw light upon the matter. One is the individual form and development of the several olenellid species; the other is the associated species found in the several faunas.

Criterion of Structure and Development.

Among the olenellid trilobites which have been found actually to precede Paradoxides, there are two principal types, one represented by *Holmia kjerulfi* and the other by *O.* (*Callavia*)§ *bröggeri* and *O.* (*Schmidtia*) *michwitzi;* and although the latter is separated to another sub-genus on account of its thorax, if we regard the head-shield, and especially the glabella, we shall be inclined to associate it with the second of the above species rather than with the first. And this is probably

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* I confess to having been influenced by this tendency myself in former years, as we then had not come to appreciate the individuality of the pre-Paradoxidean genera as we now do.

†The Fauna of the Lower Cambrian or Olenellus Zone. Extract from the 10th Annual Report, U. S. Geol. Survey, pp. 572 to 575.

‡In Bohemia, France and Spain.

§I propose this subgeneric name for *O. bröggeri* and *O. callavii* because the glabella differs from *O.* (*H.*) *kjerulfi*, etc.

the natural arrangement, as, if we may judge by the analogy of the young of other trilobites, the generic features of the head-shield would have been developed, before the posterior segments of the body were defined. Such being the case we should look upon the characters of the head-shield as of vital importance in defining relationships of the trilobites. In this view it seems natural to look upon *O. michwitzi* as the oldest form known of the root stock of Olenellus, and to associate with it, as somewhat nearly related, *O. callavii* and *O. bröggeri*.

In a discussion of the age of the Olenellus fauna it should be borne in mind that only *O.(C.) bröggeri* and *Holmia kjerulfi* have been found in actual infra-position to Paradoxides. But there are several things which indicate the antiquity of *O. michwitzi*, *e. g.*, the long cylindrical glabella, the short pleura and the small size. On the other hand the differentiation of the thorax into two regions and the great thoracic spine, show that we are not dealing with the earliest representative of the stock.*

The branch of the olenellid stem to which *O. michwitzi* belongs, if we limit it to the three species above referred to, is pre-paradoxidean, and none of its species enter the Paradoxides zone. But can we say the same of the stock at the base of which we find *Holmia kjerulfi* ? This branch of the olenellids is characterized by an enlarged front to the glabella after the manner of Paradoxides; the feature is well marked in *O. (Elliptocephala) asaphoides* and is less distinctly shown in *O. (Mesonacis) vermontana*; and although Mr. Walcott includes the former species and the associated genera in his Olenellus fauna, he intimates that they may be of the "Middle" Cambrian, *i. e.*, Paradoxides zone.

In *M. vermontana* we seem to have the highest expression of this type of structure in a trilobite apparently adapted for living on a muddy bottom. With some primitive features, as for example, the long glabella, there are others which show an advanced stage of development, as the shortened eye-lobes, the numerous joints to the thorax and the differentiation of this part into two regions. This species, according to Wal-

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*On account of these features, Peach thinks this species more modern than *Holmia kjerulfi* in which there is an equal development throughout; but for the reasons given above, and others, I do not concur in this view.

cott, belongs to the Olenellus fauna, being associated with the original Olenellus of Hall.

There still remains another group of olenellid trilobites represented by the type species and remarkable for their telson-like pygidia. All these have the enlarged Paradoxides-like front to the glabella. Are they to be referred to *Holmia kjerulfi* branch of the olenellid stock or to an ancestral type unknown? We think to the latter. This seems to have been a branch which has left widespread evidences of its distribution, having been found in Scotland and both in the east and west of America, but *nowhere has it been seen beneath the Paradoxides beds.* It is a branch of the olenellid stock, whose position relative to Paradoxides has yet to be determined. That it is a highly developed branch of the olenellids may be inferred from its glabella and peculiar pygidium, and we therefore think it is not the oldest.

From the study of the youngest of Paradoxides we judge that the enlargement of the front lobes of the glabella in this genus and in Olenellus is not a primitive character. It is not analogous to the enlarged front of the axial lobe of the cephalic shield seen in the protaspis and early larval stage of many trilobites, for we find that in the larval condition of Paradoxides these lobes are shorter than in the adult forms. Notwithstanding the difference in the facial suture we feel that Paradoxides and Olenellus are not far removed from each other, and that the enlarged front of the glabella in both points to a similar development in the two genera in this respect. Nor can we suppose that the spine-like pygidium is a protaspid character in Olenellus (*sensu stricto*); we would rather expect to find that in the early stages of growth this branch of the olenellids would be found to have a normal pygidium like that of the other two branches of the stock.

Peach, who has written on the question of the relations of the different forms of the olenellid stock to each other,* looks upon *H. kjerulfi* as the initial form of the olenellids, but we must remember that this form is in the beds which in Sweden lie immediately beneath the Paradoxides beds. A thickness of only six feet separates the two faunas, and there is no physical break between them.

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*Addition to the Fauna of the Olenellus Zone of the Northwest Highlands, by B. N. Peach., Esq., Quart. Jour. Geol. Soc., Nov., 1894, p. 671.

We think the *Schmidtia michwitzi* stock older, and imagine there is a parallel in the development of the olenellid stem similar to that which is seen in the paradoxidean. Protolenus is undoubtedly older than Paradoxides, but is very similar in structure, differing most markedly in the form of the glabella which is cylindrical in place of club-shaped. A similar relation holds in Olenellus, for the branch stock which contains *S. michwitzi*, *O. callavii* and *O. bröggeri*, with cylindrical glabellas, is the only branch of the olenellids *which is entirely below Paradoxides.* Protolenus, in this respect, bears the same relation to Paradoxides.

Some of those branches of the olenellid stock (as *Holmia kjerulfi*) with enlarged glabellas, and uniform development as regards the thorax, are also below Paradoxides. We may now inquire how far the genera of trilobites, brachiopods, etc., associated with the olenellids throw light on their position relative to Paradoxides.

Criterion of the Associated Genera.

Mr. Walcott's "Fauna of the Olenellus Zone" consists essentially of the fossils gathered from four distinct areas: 1, West Vermont to Labrador (and eastern Massachusetts ?); 2, Newfoundland; 3, Eastern New York; 4, Western America.*

The age of the Olenelli in the 4th area will depend upon the decision as to the age of those of the first area. The species of the 2d are clearly beneath the Paradoxides beds, but they do not belong with Olenellus, *sensu stricto.* The fauna of the 3d area, that of eastern New York, may now be considered. In previous publications the author has casually referred to some of the species of this fauna, and they are in evidence in relation to the subject of this paper.

Bad figures and distorted specimens for a long time left the relations of Emmons' *Atops trilineatus* in doubt, and it was only when Ford's assertion that it was a Conocoryphe was supported by Walcott's excellent figures of the better specimens, that the relations of this species became apparent. Conocoryphe, as we know, is in Europe a genus of the Paradoxides beds, and it is especially abundant in the Lower Paradoxides beds; neither in Europe nor America do we know of it below this horizon, and it is so prominent a genus of this zone that Angelin, disregarding the Paradoxides, called the zone, *Region of Conocoryphes.*

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*Fauna of the Lower Cambrian or Olenellus Zone, p. 574.

Conocoryphe shows considerable subordinate variation of form, under which several species have been established, but Emmons' species, in its sharply cut glabella furrows and other particulars, comes nearer to *C. striata* of the *P. tessini* sub-zone in Bohemia, and to a form from the *P. davidis* sub-zone in Newfoundland than to the older Conocoryphes of New Brunswick and Sweden; thus its nearest allies are in the Middle Paradoxides beds.

Another genus which occurs in the Olenellus beds of eastern New York is Microdiscus. There are two forms of this genus in the Paradoxides beds, one with ribbed side lobes to the pygidium, the other with smooth; both have long occipital spines. The form with smooth side lobes is the later of the two, and belongs to the Middle Paradoxides beds. It is to this latter that the species (*M. connexus*) which occurs in the New York Olenellus beds is related.

Three species of Agnosti are reported from these beds in New York, which also is a link with the Paradoxides beds, as no Agnosti are known in Cambrian measures older than those which contain Paradoxides. The species described by Ford is of the *Laevigatus* section of Agnosti, which is not found lower down than the Middle Paradoxides beds. Walcott says this species is a Microdiscus; it is certainly difficult to understand as an Agnostus but more so as a Microdiscus. This may be due to imperfection of the figure, or obscureness of the original specimen. The type is lost, and the author of the "Olenellus Fauna" retains it where Ford placed it.

The other two species of Agnosti are referred to the *Fallax* section of that genus, a section ranging upward through and above the Paradoxides beds, but not known below them.

Another fossil which is very common in the Paradoxides beds and occurs also in eastern New York, is Linnarssonia (*L. taconica*). This shows very little difference from *L. transversa* and *L. sagittalis*, the corresponding forms of the Paradoxides beds on the two sides of the Atlantic.

These comparisons might be extended, but I think they are sufficient to show that *Olenellus asaphoides* (the *Elliptocephala asaphoides* of Emmons) with its associated fauna, above described, must be placed in the Paradoxides zone.

We come to speak now of *the* Olenellus fauna, namely, the forms associated with the trilobites to which the name Olenellus was originally given by Hall, and here we meet with greater difficulty because we find fewer characteristic species comparable with those of the Paradoxides beds. We may, however, offer some broad generalizations.

The genus Ptychoparia is one which enters largely into this fauna, so we find no less than eight species referred to it (two doubtfully). The genus is one which in typical, or in nearly related forms, ranges through the Cambrian system, but it is not reported from the Newfoundland pre-Paradoxides beds, nor does it so occur in England or Scandinavia. One example is reported from Bohemia in a conglomerate immediately beneath the Paradoxides beds. This genus does not indicate a pre-paradoxidean age, for the beds in which it may be found—at least where the remains are abundant.

Olenoides marks a group of trilobites very like Dorypyge of Dames, a Cambrian genus found in China, which, with its associated genera, Dames compared to the fauna of the Andrarum limestone of Sweden (Upper Paradoxides beds). In Zacanthoides we have a type of trilobite comparable with Middle Cambrian forms of western America. *Protypus hitchcocki* will bear comparison with *Ellipsocephalus germari* of the Paradoxides beds of Bohemia, and Pompeckj describes a Protypus (an obscure example) from a conglomerate at the base of the Paradoxides beds in that country. *Protypus hitchcocki* and *P. senectus* are not of the same genus. *P. senectus* is a Dolichometopus, a genus characteristic of the Andrarum limestone (Upper Paradoxides beds).

Something may be said also of the *brachiopods*, though as a rule the genera of this class have a wide vertical range, and so are of less value for close correlation. Among these the common occurrence of orthids would indicate that the range of the Olenellus fauna was not much below Paradoxides. In very few countries have orthids been found below this zone. In Bohemia the genus has been found in the conglomerates just below it. Orthis is absent from the Protolenus fauna unless a single doubtful valve may indicate it.

Kutorgina occurs in the Upper Paradoxides beds of Sweden and the Lower Paradoxides beds of New Brunswick, and is reported as occurring with *O. callavii* in England. Acrothele ranges through the Paradoxides beds, also above and below them, and so gives no help; and so of Lingulella and Obolella.

Gathering the indications available from the genera of the Olenellus fauna of the original district in Vermont and its extension eastward, (the true habitat of the original Olenellus fauna) they seem to the writer to indicate that this fauna should be placed either at the summit of the Paradoxides beds; or be considered as a fauna living cotemporaneously with Paradoxides, but under different conditions of temperature and other surroundings. Walcott calls it a littoral fauna, but so to some extent is the Paradoxides fauna, especially the earlier species. If the faunas were cotemporary then it would seem that a land barrier, or difference of temperature of the sea, must have kept them apart. The former conjecture cannot be sustained if the Attleboro (Mass.) fauna pertains to the Olenellus assemblage.

There remains for consideration the Olenellus fauna of west America. Here we again meet a commingling of Middle Cambrian forms* with the genus Olenellus, so that we are left in doubt as to whether these are cotemporary with Paradoxides, or are later than it; but whatever be the horizon for *Olenellus thompsoni* and its fauna, to this the western species will naturally conform.

On the ground of the greater simplicity of the Scotch species, Peach is of the opinion that the genus Olenellus originated in Europe and spread to America. This view finds support on other grounds than he urges, viz: (1st) comparative size of the species on the two sides of the Atlantic, and (2d) the greater complexity of the American Olenellus fauna.

It is a rule that holds good for various genera of trilobites, *e. g.*, Paradoxides, Dicellocephalus, Triarthrus, that the early species are small and as later ones arise they exhibit larger species which flourish for awhile and then suddenly disappear or may be represented in depauperated or greatly modified forms. Both of the Scotch species of Olenellus are small, and they are associated with a minute trilobite (*Olenelloides*) allied to the olenellids, but showing some remarkable larval characters in the adult, as cylindrical glabella, lateral cephalic spines, short pleuræ. But with these are others of advanced type, as long posterior lobes to the cephalic rachis and shortened eyelobes.

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*Kutorgina, Orthis, Zacanthoides, Crepicephalus (and Oryctocephalus ?).

With this single genus of trilobites there are a Hyolithes and a Salterella, the whole forming, with Olenellus, a very meagre fauna. But on the western side of the Atlantic this fauna was reinforced by numerous forms from various classes of the animal kingdom; among the trilobites are Solenopleura, Ptychoparia, Agraulos,* genera which range from the horizon of *O. bröggeri* in Newfoundland (also from just beneath Paradoxides in Bohemia) upward through the Paradoxides beds.

This enriched fauna is replete with genera which find their home in the Paradoxides beds both in the lower and upper part.

Following this fauna further west, the associated trilobites in Nevada have a still more modern aspect;† we are therefore tempted to think that Peach is right in his foreshadowings of the migration of this stock.

But at the same time is there not some meaning in the association of so many paradoxidean genera with the Olenellus fauna, genera which it appears to have picked up in its journey from the east‡ (supposing it to have come from that direction).

On the same ground one might conjecture that there had been a migration of the *O. mickwitzi* branch; for that species is small compared with *O. callavii* and *O. bröggeri*, and it stands alone, there being no other trilobite recorded as occurring with it. But the third form (*O. bröggeri*) is grouped with a rich company of trilobite genera.

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*The early species referred to the genus (chiefly sub. gen. Strenuella) are not very closely related to the typical faunas in the Paradoxides beds; Protagraulos of the Protolenus fauna is nearer the line of development of the typical species.

†*Olenoides quadriceps*, *Zacanthoides lævis*. *Ptychoparia subcoronata* (like a Euloma or Anomocare), *Crepicephalus augusta*, *C. liliana* with pygidium spined like those of the Upper Cambrian, *Oryctocephalus primus*, with olenoid glabella and complicated pygidial structure.

‡The writer's views relative to the possible cotemporaneity of the Olenellus and Paradoxides faunas, are outlined in Trans. Roy. Soc. Can., vol. x, sec. IV, p. 10.

The same condition in a less degree marks the third branch of the olenelloid stock (*Holmia kjerulfi*) which starts out in Norway and Sweden with only a few trilobite genera, all of ancient type, but becomes associated with more abundant and modern forms in America, *i. e.* the faunas with *O. asaphoides* and *O. vermontana*.

The following table is intended to express the supposed relations of the various branches of the olenellid stem to Paradoxides, as outlined in the preceding article. It is assumed that *O. thompsoni* and *M. vermontana* mark a separate subfauna from *E. asaphoides;* if they should prove to be of the same sub-fauna as the latter, this should be placed higher up in the table. The transverse line of the table is the base of the Paradoxides beds.

To sum up the results of this review it may be said that the fauna of the Olenellus zone as set forth by Mr. Walcott, contains four elements:

1st—A fauna that is pre-paradoxidean but contains no Olenellus (*sensu stricto*).—Newfoundland.

2d—A fauna of the age of the Paradoxides beds—that of eastern New York.

3d—A fauna whose place is uncertain, but probably at the summit of the Paradoxides beds,—that of western Vermont and the St. Lawrence valley.

4th—A fauna nearly cotemporary with the last, but perhaps later—that of several districts in the western part of North America.

The above article records some facts, some inferences and some conjectures; if the last gain support from the first, the whole favors the view expressed by the author some years ago, in this journal, that the Cambrian system (at least so far as the Atlantic basin is concerned) is naturally divided into two parts (not three) so far as the faunas are concerned;* the lower marked by the "giant Oleni," the upper by the depauperated forms of this family. This was the verdict of Salter

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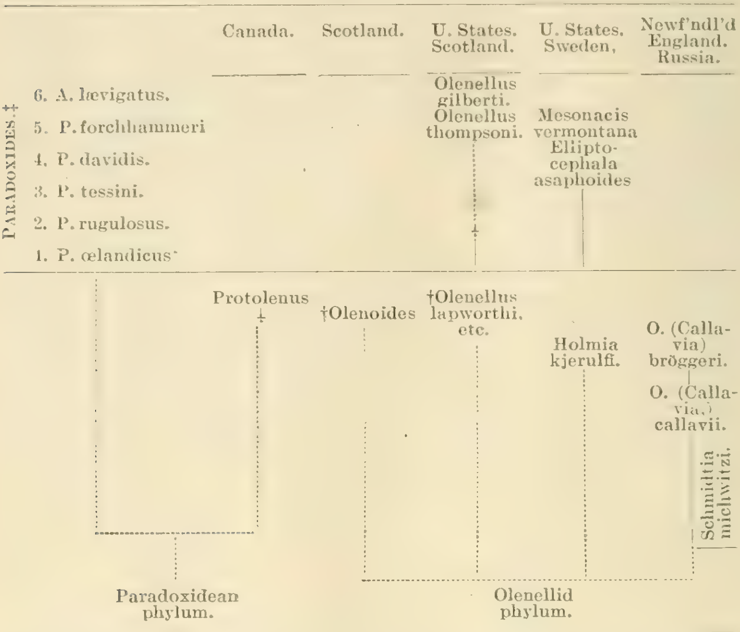
*How is the Cambrian divided? A plea for the classification of Salter and Hicks.

Theoretical view of the supposed relation of the Olenellid Faunas and the Protolenus Fauna to Paradoxides.



and Hicks after their study of the Welsh Cambrians, and it is equally applicable to those of eastern Canada. A glance at the preceding table will show how difficult it is to draw the line which shall separate the Olenellus from the Paradoxides fauna on this side of the Atlantic, whatever may be the conditions in Europe, or the exigencies of classification in western America.

POSTSCRIPT.—I find that I can say something more definite about the place of the Olenellus fauna.

In the last few days I have been examining the material of a new sub-fauna of the Paradoxides beds of the St. John group. It is from irregular layers of limestone in the Kennebecasis valley, and besides a paradoxidean form of which the material is defective, it contains abundance of Ptychoparia. Solenopleura and Anomocare. *Agnostus brevifrons* is common, and *Agnostus parvifrons* occurs. *Dorypyge* is present, also *Dolichometopus*. It is in fact the fauna of the *Andrarum limestone* or Upper Paradoxides beds of Sweden.

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†*Olenoides* and *Olenellus lapworthi*, though placed in this table below the Paradoxides beds, are not actually known to hold this relation, they may be higher up in the Cambrian system than they are here represented to be.

‡The divisions of the Paradoxides beds given here are those of the north of Europe.

One Dorypyge is very like *Dicellocephalus (?) marcoui* Whitfield=*Olenoides marcoui* of Walcott, and there is also a form near *Protypus senectus* of the same author. These are strong points favoring the view that the Olenellus fauna of Vermont is of the age of the Upper Paradoxides beds of Sweden. And in this connection I may add that though Conocoryphea are specially characteristic of the Lower Paradoxides beds, they are also found in the Upper, and that a form which in its sharply cut glabellar furrows and in other respects resembles *Atóps trilineatus*, is found in the *P. davidis* fauna in Newfoundland. This fauna, so far as America is concerned, is in the Upper Paradoxides beds.

It is somewhat significant that the European faunas, known to be older than Paradoxides are *poor in genera of trilobites;* the Russian has one genus, the Swedish three, the English two; and although that of Newfoundland seems to have more, this may be susceptible of explanation. In general terms it may be said that the fauna of Olenellus is *too rich* in varied types of trilobites and in articulate brachiopods to be preparadoxidean.

St. John, N. B., 6th April, 1897.

LAKES WITH TWO OUTLETS, IN NORTHEASTERN MINNESOTA.*

By U. S. Grant, Minneapolis, Minn.

A paper by T. L. Watson on "Lakes with more than one outlet"† has suggested to the writer that a mention of other lakes of this character might be of interest. Several such lakes are known in the northeastern triangular area of Minnesota included in Cook, Lake, and St. Louis counties, and it is not improbable that others will be noted when that part of the state is explored more carefully. Information concerning most of these lakes and their outlets was obtained while the writer was engaged in field work for the Geological and Natural History Survey of Minnesota.

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*Read before the Minnesota Academy of Natural Sciences, May 4, 1897.

†Amer. Geol., vol. xix, pp. 267-270, April, 1897.

Brulé lake (1851 feet above the sea) is a sheet of water over eight miles (including its narrow eastern part) in length, east and west, and averages about a mile in width. It is situated in Ts. 63-2 and 63-3 W., Cook county, and is about twenty miles north of lake Superior. The fact that this lake has two outlets, one at the east and the other at the west end, has already been noted by C. P. Berkey.* The two outlets form streams of approximately equal volume, and both flow over rock beds. The eastern stream is the Brulé river which, after an east-southeasterly course of some forty miles, enters lake Superior in T. 62-3 E. The western stream finds its way into the Temperance river whose mouth is forty-three miles southwest of that of the former stream. The water which flows through the second outlet travels over thirty miles before reaching lake Superior.

A small lake on the International boundary stream which connects Gunflint and Saganaga lakes, in Cook county, has two outlets which have both been figured and one of them described by A. Winchell.† This lake (about 1512 A. T.) is of only a few acres extent and is situated (Sec. 19, T. 65-4 W.) in one of the most forbidding and desolate spots imaginable, the land surface being bare granitic ledges, white and glistening, from which the vegetation and the slight covering of soil have been removed by fires. The two outlets are less than half a mile apart and both flow westward into Pine lake, about half a mile distant.

The Kawishiwi river, a westward flowing water course in the northern part of Lake county, is formed by a series of lakes connected by short, rapid streams. At least three of the lakes of this series have each two outlets. The largest body of water of this nature along this river is a very irregularly outlined lake (about 1503 A. T.) which sends its arms and bays into fifteen different sections in Ts. 62-9, 63-8 and 63-9 W.

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*Geol. and Nat. Hist. Survey of Minn., 22d Ann. Rept., pp. 137-138, 1894.

†Ibid., 16th Ann. Rep., pp. 230-232, 1888.

Its two outlets are more than a mile apart and the water flows west through one and north through the other into Crab lake (about 1487 A. T.), the next lake of this series. This lake is of the same general nature as the last, being of very irregular outline and entering seven sections in T. 63-9 W. The two outlets of Crab lake are less than a mile distant from each other in a direct line, but some three miles by the course which the water takes from the main body of the lake to the two outlets. Another lake (about 1451 A. T.) of the same character is comprised in seven sections in the southeastern part of T. 63-10 W. It has one outlet on the south and one on the west. The water which passes through the former flows southwest to Birch lake and then north to White Iron lake* and joins the water from the second outlet about six miles west of the parent lake, after having traveled some twenty miles. Mr. A. H. Elftman informs the writer that another one of the Kawishiwi River lakes, has, in times of high water, two outlets about a mile apart, but only one normally. This lake is a mile and a half long and is situated in sections 20 and 21, T. 63-8 W.

Iron lake, Lac la Croix and Namekan lake, three lakes on the International boundary between St. Louis county, in Minnesota, and Ontario, each have two outlets.† The main outlet of the first flows north of the boundary through McAree lake and joins the boundary waters again in Lac la Croix. During high water and a stage of water only a little above the normal, Iron lake also has an outlet which flows westward and enters Lac la Croix about five miles south of the other outlet. The main outlet of Lac la Croix is the Namekan river which flows from the north side of the lake. During high water another stream leaves the southwest corner of the lake and follows the International boundary to Namekan lake into which flows the Namekan river. The land included between these two outlets of Lac la Croix, from this lake till they join again in Namekan lake, is some one hundred and twenty five square miles. And Namekan lake itself has two outlets of about equal volume and less than half a mile apart, but in no way connected. Both streams flow over rock beds into Rainy lake.

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*The location of the lakes mentioned in this paper can be found on the map which accompanies the 15th Ann. Rept. Geol. and Nat. Hist. Survey of Minn.; also the map accompanying Bulletin 6 of the same Survey. They can also, with the exception of the first two, be found on the Hunter's Island sheet published by the Geological Survey of Canada.

†Cf. U. S. Grant. "The International boundary between lake Superior and Lake of the Woods," Minn. Historical Soc. Collections, vol. 8, pt. 1, pp. 1-10, 1895.

The question of the origin of these lake basins need not be discussed here; it is sufficient to consider that, after the departure of the ice sheet, there were certain basins (in drift, in rock, or in both) in each of which water accumulated until it overflowed the rim of the basin. In a few cases a basin had two points in its rim of the same altitude and lower than any other point, and thus a double outlet to the lake was formed. If one or both outlets flowed over drift deposits in all probability one of them would be of short duration; that there were formerly some such lakes is not improbable. However, in the case of the lakes here described many, if not all, of the outlets flow over rock beds. The country in which they lie is one where nearly all traces of weathered rock have been removed by glacial erosion, and the present rock surface is sound and unweathered and usually of the same character (as regards rock species, grain, hardness, etc.) at each of the outlets of any lake. Comparatively little sediment is brought into any of the lakes and practically all this small amount is deposited soon after its reception, so the water flowing from the lakes is almost entirely free from sediment and thus nearly powerless to cut into hard rock. It may therefore be concluded that these lakes will be of comparatively long life and, moreover, that the possession of two outlets will be, unless the cause mentioned below operates, a feature of long duration.

A possible cause for the brief duration of one outlet is to be found in differential elevation. It is well known that certain portions of Minnesota have been elevated since the formation of the beaches of the glacial lakes Agassiz and Warren, and, if the movement is still in progress,* some of the larger lakes here described will most probably loose one of their outlets in a comparatively short time. If northern elevation is still in progress the southern outlet of Lac la Croix; which is at present used only in high water, will become a normal outlet and the northern will be diminished in volume, or perhaps entirely abandoned.

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* Cf. Robert Bell. "Evidences of northeasterly rising of the land along Bell river," Bull. Geol. Soc. Amer., vol. 8, pp. 241-250, pls. 23-24, Mch. 12, 1897.

In this connection it is of interest to consider the relations and time of duration of the two outlets of Brulé lake. Twenty miles to the south of this lake are the ancient beaches on the north shore of lake Superior, the highest of which has been stated to have a northeasterly elevation averaging seven inches to the mile.* This same elevation at Brulé lake, which is about eight miles long in an east and west direction, would cause the water at the western end to stand over three feet higher than formerly—an amount more than adequate to cause an overflow at that extremity of the lake. From the drowned character of the St. Louis River valley at the western end of lake Superior it is clear that that end of the lake has been relatively lowered several feet since the present outlet at Sault Ste. Marie was established, and it certainly seems probable that this differential elevation is still in progress.† From the foregoing it may be reasonably assumed that Brulé lake, shortly after the departure of the ice-sheet from this region, had but one outlet and that toward the east; that later elevation of the eastern end of the lake caused a part of the water to overflow a depression in the western rim of the basin; that continued differential elevation brought this outlet into equal prominence with the first; and that the continuance of this process will cause the first outlet to be abandoned entirely, thus making a marked change in a minor drainage feature of this part of Minnesota.

RHYTHMIC ACCUMULATION OF MORAINES BY WANING ICE-SHEETS.

By Warren Upham, St. Paul, Minn.

North American and European Series of Marginal Moraines.

Definite marginal accumulations of drift are absent or very rare on the extreme boundaries of the great ice-sheets which in the Glacial period enveloped the northern half of North America and northwestern Europe. The margin of the drift on each continent is mainly attenuated. In some parts it is represented only by scattered boulders. The outermost till deposits often occur in patches, with intervening tracts which were doubtless covered by the border of the ice-sheet, but received little or no drift.

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* Warren Upham. Geol. and Nat. Hist. Survey of Minn., 23d Ann. Rep., p. 164, 1895.

†Cf. Warren Upham. *Op. cit.*, p. 171.

At varying distances of a few miles to two or three hundred miles back from the limits of glaciation, the drift is amassed in prominent knolly and hilly belts which are traced hundreds of miles along the boundaries held by the North American and European ice-sheets after they had thus considerably waned from their maximum areas. Once inaugurated by the formation of the first and outermost marginal moraine, this stage or epoch of the Ice age was thenceforward characterized on both continents, by a rhythmic accumulation of morainal belts of ridges and hillocky drift, with far more abundant boulders than are found on the intervening tracts where the drift is spread with a smoother surface.

The Minnesota lobe of the North American ice-sheet, in its recession 450 miles from Des Moines, Iowa, to Vermilion lake in northeastern Minnesota, formed twelve moraine belts, which I have mapped for the Minnesota Geological Survey, averaging about forty miles apart along the axis of this lobe. Upon its sides the series of moraines is crowded closer together, and many irregularities of the glacial retreat with re-advances, are shown by blended and overlapped moraines. The correlative series of moraines in Illinois, Indiana, Ohio, and Michigan, traced by Leverett, Taylor, and others, comprises a somewhat larger number of separate marginal belts, with less average distance between them.

What recurring conditions caused these moraines to be amassed successively, one after another, to the number of twelve to fifteen or more in the northern part of the United States, with others, partly known but less fully traced and mapped, farther north in Canada? It is evident that the most southern and outer moraine is the oldest, and the others successively newer in their order from south to north; for if any member of the series had been covered by a re-advance of the ice-sheet, its uneven contour would have been much smoothed down. The moraines therefore record a somewhat regularly rhythmic action of the waning ice-sheet. Was this dependent on the repetition of secular variations of climate? or was it due to regular varying physical conditions of the wasting border of the ice-sheet, in combination with the exposure and deposition of its previously inclosed drift?

RAPID FORMATION OF MORAINES SHOWN BY THEIR RELATION TO LAKE AGASSIZ.

My studies of the glacial lake Agassiz convince me that the moraines were, in a geological sense, very rapidly formed. Four or five large moraines in northern Minnesota and North Dakota were accumulated, in succession, contemporaneously with the formation of the highest or Herman beach of this glacial lake. The time occupied in the accumulation of any one of these moraines was probably no more than a few decades of years; for the entire duration of lake Agassiz, marked by a series of thirty shore-lines, appears, from the total amount of wave erosion and resulting deposition of beach gravel and sand, to have been only about a thousand years.* Ten times as much wave action during the Postglacial period is shown by the shores of the great Laurentian lakes.

DERIVATION OF THE MARGINAL MORAINES CHIEFLY FROM ENGLACIAL AND SUPERGLACIAL DRIFT.

Such rapid accumulation of the marginal moraines, their exceptional abundance of boulders, and their occurrence as steep hills and ridges which rise abruptly to hights of 100 to 300 feet, all point to their derivation chiefly from drift which was inclosed in the lower part of the ice-sheet. When ablation had thinned the ice to its basal third or fourth part, in which drift was held and borne forward, the ice surface, in its being further melted, became overspread by a covering of drift. In a former paper† I have attempted to show how this drift could be amassed in large marginal moraines during a few years or decades, as is implied on each side of lake Agassiz.

RETARDATION OF THE ICE MOVEMENT BY ENGLACIAL DRIFT.

The growth of a forest on the border of the Malaspina ice-sheet, to a distance of three to five miles from its edge, with hundreds of feet of ice beneath the superglacial drift and its

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*U. S. Geological Survey, Monograph xxv, 1896, pp. 240-244.
†AM. GEOLOGIST, vol. XVI, pp. 107-113, Aug., 1895.

growing trees, proves that the ice border there is nearly or quite stagnant. Russell, the explorer of that ice-sheet, has directed attention to the hindrance of glacial currents by inclosed drift.* It seems to me probable that this principle may explain the stagnation of the forest-covered ice in Alaska, and also a slackening or cessation of movement in the outer zone of the waning Pleistocene ice-sheets, to which the eskers of many districts appear to bear testimony.

EFFECT OF SUPERGLACIAL DRIFT TO DIMINISH ABLATION.

It is further evident that the covering of drift on the outer part of the melting and receding ice-sheet protected it in a degree from ablation by the sun's heat and by rains. On this outer zone of the ice, impeded in its movement by its continued drift, melting was diminished, as compared with its earlier progress to the depth where it exposed the upper part of the drift; and as more of the englacial drift became superglacial, the melting beneath proceeded yet more slowly.† This condition may have been true for a belt reaching back ten to twenty miles, or even, as I think, in some places fifty miles, from the extreme edge of the drift-covered ice, although in a decreasing degree the farther it extended. In other words, I believe that retardation of the ice movement by englacial drift, generally reached across the belt, of variable width, from one moraine to the next.

PARTLY CONTEMPORANEOUS ACCUMULATION OF SUCCESSIVE MORAINES.

While the border of the ice-sheet was sluggishly dissolving, strong glacial currents, favored by abundant snowfall and steepness of the ice slope, were efficient in the contiguous higher zone of the ice-sheet, including the upper part of the englacial drift and the clear ice of greater hights, to bear much of that drift forward to become superglacially amassed at the inward limit of the drift-enveloped ice. In this upper moraine, far travelled boulders would be plentiful, and sometimes they would be almost unmixed with any boulders or finer drift of local or near derivation, as Chamberlin describes certain remarkable boulder belts in Ohio, Indiana, and Illinois.* Where the ice enclosed much drift, even these upper superglacial accumulations, ten to fifty miles back from the edge of the ice beneath the drift, may have attained a considerable depth, perhaps forming hills 100 feet or more in hight, before the deepening ablation exposed the englacial drift farther back, so that the next succeeding morainal line would begin to be established.

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*Israel C. Russell, "The Influence of Debris on the Flow of Glaciers," Journal of Geology, vol. III, pp, 823-832, Oct.-Nov., 1895. This admirable discussion and other helpful suggestions, relating to superglacial drift, given by J. B. Woodworth in the AM. GEOLOGIST, vol. XVIII, pp. 166, 167, Sept. 1896, have been the incentives of the study here presented. Prof. Russell's new book, "Glaciers of North America," first seen by me after this paper was written, treats (in pages 25-28 and 156-159, etc.) of the influence of inclosed and superglacial drift on the advance and retreat of ice-sheets.

†Prof. N. H. Winchell, writing in the Popular Science Monthly for July, 1873, (vol. III, p. 293, 294), held that the border of the waning North American ice-sheet was concealed under drift, nearly as the margin of the Malaspina ice-sheet has been found by subsequent exploration. Compare my paper on "Englacial Drift," in the AM. GEOLOGIST for July, 1893, (vol. XII, pp. 36-43).

Until such a later and higher moraine began to be formed, the basal glacial currents probably acted also very efficiently to carry forward much of the lower englacial drift and to heap it subglacially or englacially beneath the upper moraine. With the beginning of another and higher surface moraine, the belt of accumulation by the basal currents would be shifted inward to coincide nearly with the new superglacial accumulation.

In the outermost zone of the waning ice-sheet, movement would be feeble or would wholly cease, as Russell suggests, because of the previous amassing of much englacial drift there. The basal currents farther back must accordingly pass upward, carrying some drift to the surface. During a long time the chief growth of a moraine belt took place, according to my view, at a distance of several or many miles back from the edge of the ice beneath the drift. When, in the gradual progress of ablation, a new and inner moraine began to be amassed, the outer one soon ceased to receive additions, or they were comparatively insignificant, on account of the slackened currents or stagnation of the outer ice zone. Finally, the combined superglacial and englacial or subglacial morainic accumulations, by the melting of the ice between them, became strictly a marginal or terminal moraine.

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*Journal of Geology, vol. I, pp. 52-60, Jan.-Feb., 1893.

Where tracts of abundant drumlins, as in southern New Hampshire, Massachusetts, and New York, occur, extending as they almost invariably do, approximately in parallelism with the great moraine belts, we may explain their origin, as I think, by an overflow of the upper, steeply sloping, snow-fed icefields upon the previously drift-covered ice of the outer zone, heaping its drift in these remarkable hills.*

RHYTHM OF MORAINAL ACCUMULATION INDEPENDENT OF SECULAR VARIATIONS OF CLIMATE.

The progress of ablation during the departure of the ice-sheet appears to have been mainly continuous through many years and centuries, excepting as it was temporarily interrupted during each winter. It was undoubtedly accelerated or decreased in cycles of several or many years by secular variations of climate, such as now give series of years leaving alternately a deficiency and an excess of rainfall and snowfall. But these secular climatic changes need not be appealed to for explanation of the rhythm of morainal accumulation. With an entirely regular melting away of the ice-sheets, the recurrence of prominent moraines, with smooth intermorainic tracts, seems to me well explainable by the physical conditions dependent on the action of the glacial currents in amassing successive belts of the drift inclosed in the lower 800 to 1,500 feet, more or less, of ice that had attained a thickness of a half mile to one mile.

PROBABLE DURATION OF THE CHAMPLAIN EPOCH OR WANE OF THE ICE AGE.

This explanation accords with my conclusion concerning the brevity of the existence of lake Agassiz, and with the generally accepted time ratios and estimates of the Glacial and Postglacial periods, as respectively, between 40,000 and 100,000 years, and between 5,000 and 10,000 years. It seems to me more acceptable than the reference of the successive moraines to climatic cycles of astronomic origin, by which Taylor† conjectures that a duration of 150,000 to 300,000 years was required for the formation of the moraines in the northern United States, not to speak of others in Canada.

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*AM. GEOLOGIST, vol. x, pp. 339-362, Dec., 1892. Bulletin, Geol. Soc. Am., vol. VII, pp. 17-30, Nov., 1895.

†AM. GEOLOGIST, vol. XIX, p. 290, April, 1897.

According to the view presented in the present paper, all the continental moraines were probably amassed during a few thousand years, terminating the Glacial period, while the ice-sheets were being melted fast (as geologists reckon time) because of the Champlain depression of the ice-enveloped lands of both North America and Europe.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Occurrence of Copper Minerals in Hematite Ore, Montana Mine, Soudan, Minnesota. Description of the Occurrence, by J. H. EBY. *Study of the Minerals*, by C. P. BERKEY. (Trans. Lake Superior Mining Inst., 1896, vol. IV, pp. 69-79.) The Montana mine is in a body of hard bessemer hematite, on the Vermilion iron range. Copper minerals were here first noted in a nearly horizontal seam, one-fourth to one-half inch in thickness, in the hematite, and 265 feet below the surface. The minerals are native copper, cuprite, malachite and azurite, occurring in the seam and also below it, and all are later than the hematite. The original mineral was the native copper from which the others have been derived by alteration. No other occurrence of copper minerals in the mines of the Vermilion iron range is known. U. S. G.

Summary Report of the Geological Survey Department [of Canada] for the year 1896. By GEORGE M. DAWSON, Director. 144 pages: Ottowa, 1897. Price, ten cents. Fifteen field parties were employed as follows: in the Northwest Territories, Ontario, and Nova Scotia, each three: partly in Ontario and partly in Quebec, two; in British Columbia, two; and in Quebec and Labrador, each one. Concise statements of these various explorations fill the principal part of this report, with additional notes of the laboratory and office work in chemistry, mineralogy, and lithology, mining statistics, paleontology, zoology, and botany, and in mapping. Especial attention is everywhere directed to the discovery and development of the mineral resources of the country.

The boring for petroleum at Athabasca Landing, in northern Alberta, has been abandoned, on account of the difficulty and impossibility of going lower, at the depth of 1,770 feet. It is hoped to provide better means for drilling and to ascertain the depth of the oil-bearing lowest formation of the Cretaceous series, which in its outcrops farther north, where its petroleum has chiefly evaporated, is called the "tar sands."

Very interesting observations on the glacial geology of southern Quebec are presented by Mr. R. Chalmers, who reports an early stage of glaciation when icefields moved northward from the Notre Dame mountains into the St. Lawrence valley, succeeded by a time when a general ice-sheet moved from the Laurentide highlands southward and southeastward over this region. Each of these stages is represented by its striæ and stoss sides of hills, and by its boulder-clay or till deposits. The basins of the long and narrow lakes Memphremagog, St. Francis, Megantic, and others, are believed to be preglacial river valleys which became obstructed by the epeirogenic movements of the Quaternary era. Since the Champlain epoch, the St. Louis basin has been greatly uplifted, to a maximum extent, so far as it is indicated by ancient shore lines, of 700 feet, or perhaps 875 feet, in the vicinity of Arthabasca, about 70 miles southwest of the city of Quebec. Chalmers there observed three shore lines, the highest at 875 to 885 feet above the sea, the second at 700 to 720 feet, and the third at 600 to 625 feet. Investigation by a detailed survey, however, with leveling, will be requisite for determination of the question whether the upper shore may represent a fresh-water glacial lake, held by the barrier of the waning ice-sheet, which finally seems to have ceased its blockade of the St. Lawrence valley in the vicinity of Quebec city. Then a glacial lake on its southwest side, which has been named lake St. Lawrence, outflowing southward into the Hudson river, fell to the sea level of that time, which is doubtless represented at Arthabasca by the lower shores, as it is known at Montreal by marine fossiliferous beds up to 560 feet above the sea on Mount Royal.

The year's appropriations for this survey were $103,107.93, of which a ninth part was used in printing and lithography. During the year 31,595 people visited the survey museum. It is urgently requested that the Dominion Government shall provide, at the earliest practicable date, a larger and fireproof building for the extensive and very valuable collections of the survey, which have been accumulating through more than half a century. A general index of the reports of the survey is being prepared for publication, which will include about 32,000 references. W. U.

The Water Resources of Illinois. By FRANK LEVERETT. 155 pages, 6 plates, and 9 figures in the text; Washington, 1896. (Extract from the Seventeenth Annual Report of the U. S. Geological Survey, for 1895-96.) This very elaborate report on the hydrography, water power, water supplies for cities and villages, and artesian wells, throughout the state of Illinois, presents also good descriptions of the surface features of the state, with a contoured map; of its bed rocks, with a geological map and sections; and of the glacial drift, which Mr. Leverett has very fully studied, with a map showing the moraines, till plains, loess, sand areas, valley drift and alluvium, and the former extension of Lake Michigan. The early till, mainly loess-covered, occupies the western and southern two-thirds of the state, excepting a small driftless tract in the northwest corner (a part of the great Wisconsin driftless area) and a width of about 35 miles at the south, in the angle of the Mississippi and Ohio rivers, which lies outside the extreme limit of glaciation. The outer one of about a dozen marginal moraines, belonging to the later Wisconsin stage of glaciation, extends from near Terre Haute, Ind., west to Shelbyville, thence north-northwesterly to Peoria, and thence north and northeast to the western part of McHenry county, from which it passes into Wisconsin. On the northern line of Illinois a composite belt of knolly and hilly drift about 40 miles wide, represents the series of marginal moraines, which appear as many separate belts farther south and in Indiana.

In the city of Chicago about thirty artesian wells have been obtained at depths from 2,000 to 2,700 feet; and numerous other places have good artesian wells 2,000 to 2,500 feet deep. Along the Illinois river valley, on the other hand, several hundreds of artesian wells vary in depth from 150 feet, or less, to about 400 feet. It is estimated that the cities of Ottawa and Marseilles, in this valley, have each about two hundred such wells. The closely tabulated data of the artesian wells of all the state fill nine pages; and three pages are occupied in a tabulation of the chemical analyses, by the State Board of Health, of sixty-eight specimens of the waters of rivers, lakes, reservoirs, wells and springs. Many additional water analyses by other analysts, are also given in three later pages, representing many springs, shallow wells, and artesian wells. W. U.

RECENT PUBLICATIONS.

I. Government and State Reports.

California State Mining Bureau, Bull. 11, x and 94 pp., 1897. Oil and gas yielding formations of Los Angeles, Ventura and Santa Barbara counties, W. L. Watts.

II. Proceedings of Scientific Societies.

Bull. Geol. Soc. Amer., vol. 8, pp. 157-168, Feb. 22. Weathering of micaceous gneiss in Albemarle Co.,Va., G. P. Merrill.

Ibid., pp. 169-182, pl. 14, Feb. 25. The Leucite hills of Wyoming, J. F. Kemp.

Ibid., pp. 183-196, pl. 15, Feb. 27. Modified drift in St. Paul, Minn., Warren Upham.

Ibid., pp. 197–212, pl. 16, Mch. 5. Unconformities of Marthas Vineyard and of Block island, J. B. Woodworth.

Ibid., pp. 213-226, pls. 17-20, Mch. 6. Solution of silica under atmospheric conditions, C. W. Hayes; Erosion at baselevel, M. R. Campbell.

Ibid., pp. 227-240, pls. 21-22, Mch. 8. Gypsum deposits of Kansas, G. P. Grimsley.

Ibid., pp. 241-250, pls. 23-24, Mch. 12. Evidences of northeasterly differential rising of the land along Bell river, Robert Bell.

Ibid., pp. 251-268, pls. 25-29, Mch. 23. Former extension of Cornell glacier near the southern end of Melville bay, R. S. Tarr.

Ibid., pp. 269-286, pl. 30, Mch. 29. Lake Warren shorelines in western New York and the Geneva beach, H. L. Fairchild: Old tracks of Erian drainage in western New York (Abstract), G. K. Gilbert.

Ibid., pp. 287-304, Mch. 31. Age of the lower coals of Henry county, Missouri, David White.

Proc. Calif. Acad. Sci., 2d ser., vol. 6, Mch. 1, 1897. Notes on Palæozoic Crustacea, No. 5,—Carboniferous trilobites from Missouri, A. W. Vogdes: On some new Cretaceous (and Eocene?) Mollusca of California, J. G. Cooper.

Proc. Lake Superior Mining Inst., 1896, vol. 4. The occurrence of copper minerals in hematite ore, Montana mine, Soudan, Minn., J. H. Eby and C. P. Berkey

Journ. Elisha Mitchell Sci. Soc., 1896, pt. 1, 1897. River adjustments in North Carolina, W. J. Weaver.

Proc. Acad. Nat. Sci., Phila., 1897, pt. 1. The affinities of Floridian Miocene land snails. H. A. Pilsbry; The primeval ocean, Chas. Morris.

III. Papers in Scientific Journals.

Amer. Nat., Mch. Fossils and fossilization, L. P. Gratacap.

Ibid., April. Fossils and fossilization, L. P. Gratacap.

Ibid., May. The seventh session of the International Geological Congress, Persifor Frazer; In memoriam E. D. Cope, Persifor Frazer; Obituary notice of E. D. Cope, J. S. Kingsley.

Science, Mch. 12. Prof. Fontaine and Dr. Newberry on the age of the Potomac formation, L. F. Ward; Current notes on physiography, W. M. Davis; Greenland glaciers, E. H. Williams, Jr.

Ibid., March 19. Gibbers, J. B. Woodworth.

Ibid., Mch. 26. Current notes on physiography, W. M. Davis; The former extension of ice in Greenland, R. S. Tarr, T. C. Chamberlin.

Ibid., Apr. 2. The drainage of the Saginaw valley, A. C. Lane.

Ibid., Apr. 9. The origin of the teeth of the mammalia, H. F. Osborn; Current notes on physiography, W. M. Davis; Archæological discoveries made in the gravels at Trenton, G. F. Wright.

Ibid., April 16. The great fault and accompanying sandstone dikes of Ute pass, Colorado, W. O. Crosby; The Ganodonta or primitive edentates with enamelled teeth, H. F. O.

Ibid., April 23. Current notes on physiography, W. M. Davis; The coming ice age, C. A. M. Taber.

Ibid., April 30. The Quaternary of Missouri, J. E. Todd; A "driftless" ridge, O. H. Hershey.

Ibid., May 7. E. D. Cope, H. F. Osborn: Pareiasauria Seeley (Cotylosauria Cope) from the Triassic of Germany, G. Baur; Current notes on physiography, W. M. Davis.

Ottawa Nat., Feb. Recent explorations in Canada: Introductory sketch, G. M. Dawson; The barran lands, J. B. Tyrrell; The Labrador area, A. P. Low.

School of Mines Quarterly, Jan. Subterranean temperatures at Wheeling, W. Va., and Pittsburg, Pa., W. Hallock.

Scientific Amer., Apr. 3. The glaciers of Greenland, R. S. Tarr.

Amer. Jour. Sci., Apr. Acid dykes in the Connecticut Triassic area, E. O. Hovey; Granitic rocks of the Pyramid Peak district, Sierra

Nevada, Cal., W. Lingren; Difference in the climate of the Greenland and American sides of Davis' and Baffin's bay, R. S. Tarr; Foramina perforating the cranial region of a Permian reptile and on a cast of its brain cavity, E. C. Case; Plasticity of glacial ice, I. C. Russell; Affinities of Hesperornis, O. C. Marsh.

Ibid., May. Southern Devonian formations. H. S. Williams: Genus Lingulepis, C. D. Walcott; Seiches on the bay of Fundy, A. W. Duff; Rœblingite, a new silicate from Franklin Furnace, N. J., containing sulphur dioxide and lead, S. L. Penfield and H. W. Foote.

Kansas Univ. Quarterly, vol. 6. no. 1, ser. A, Jan., 1897. Restoration of Oreodon culbertsonii Leidy, Alban Stewart; Gypsum in Kansas, G. P Grimsley; On the chemical composition of some Kansas gypsum rocks, E. H. S. Bailey and W. M. Whitten; Restoration of Ornithostoma (Pteranodon), S. W. Williston; Notice of some vertebrate remains from the Kansas Permian, S. W. Williston.

Nat. Geog. Mag., April. The area and drainage basin of lake Superior, M. W. Harrington.

Bull. Amer. Geog. Soc., vol. 29, no. 1, 1897. The physical geography of New York state (pt. 2), R. S. Tarr; Economic importance of geological and physical conditions in tropical America, F. C. Nicholas.

Canadian Rec. Sci., vol. 7, no. 4. Note on Cryptozoan and other ancient fossils, Wm. Dawson; On the occurrence of cancrinite in Canada, A. E. Barlow; Hippopotamus remains, W. E. Deeks; The anorthosites of the Rainy Lake region, A. P. Coleman; On the structure of Europe, Edward Suess; Geological report and map of the district about Montreal, J. A. Dresser.

Journ. Geol., April-May. Glacial studies in Greenland, T. C. Chamberlin: Italian petrological sketches, H. S. Washington; Are the bowlder clays of the great plains marine? G. M. Dawson; The bauxite deposits of Arkansas, J. C. Branner.

IV. *Excerpts and Individual Publications.*

The faunal relations of the Eocene and Upper Cretaceous on the Pacific coast, T. W. Stanton. U. S. Geol. Survey, 17th Ann. Rept., pt. 1, pp. 1005-1060, pls. 53-57, 1896.

A summary of progress in petrography in 1896, W. S. Bayley. From monthly notes in the Amer. Nat. Waterville, Me., 1897.

Report on coal and lignite of Alaska, W. H. Dall. U. S. Geol. Survey, 17th Ann. Rept., pt. 1, pp. 763-908, pls. 48-58, 1896. (Contains appendix on fossil plants by F. H. Knowlton, on Paleozoic fossils by Chas. Schuchert, and on Mesozoic fossils by Alpheus Hyatt.)

Paleozoic outliers in the Ottawa River basin, R. W Ells. Trans. Royal Soc. Canada, ser. 2, vol. 2, sec. 4, pp. 137-149, 1896.

Notes on the geology of the Bermudas, J. J. Stevenson. Trans. N.Y. Acad. Sci., vol. 16, pp. 96-124, pls. 8-10, March 26, 1897.

The geology of the magnetites near Port Henry, N. Y., and especially those of Mineville, J. F. Kemp. Trans. Amer. Inst. Mining Eng., Chicago meeting, Feb., 1897; 58 pp., 2 pls.

The Cretaceous clay marl exposures at Cliffwood, N. J., Arthur Hollick. Trans. N. Y. Acad. Sci., vol. 16, pp. 124-136, pls. 11-14, March 26, 1897.

Report on the country between Athabasca lake and Churchill river, J. B. Tyrrell and D. B. Dowling. Geol. Surv. of Canada, Ann. Rept., vol. 8, pt. D, 120 pp., 3 pls., 1 map, 1896.

CORRESPONDENCE.

A COMPLETE OIL WELL RECORD.* Geologists have long desired a careful and accurate measurement of the rocks passed through by the borings for oil in southwestern Pennsylvania. Mr. Carbel, during the life of the Second Geological Survey of Pennsylvania, had several careful records kept of the borings in Clarion and adjoining counties, but as the strata dip to the southwest, and thicken somewhat, it was very desirable to have a new standard for comparison in southern Pennsylvania.

The writer happily found in Mr. T. J. Vandergrift of Jamestown, N. Y., a successful oil operator of many years experience, the right man to undertake the work, purely as a labor of love in the interest of geology.

The well in question was drilled by the Woodland Oil Co., of which Mr. Vandergrift is president, on the S. B. Phillips' farm, in the famous McDonald field, near the line between Allegheny and Washington counties, about 20 miles southwest from Pittsburg.

The main producing rock of this region is the lowest member of the Venango Oil Sand group, or what is known as the fifth oil sand. This rock, it will be remembered, has yielded petroleum in greater quantity than any other horizon yet found on the American continent, since some of the wells of the McDonald region produced oil, for a short time, at the rate of 15,000 barrels daily.

It is no slight task to keep one of these deep well records with the necessary care, since to be reliable a sample of the drillings must be washed, dried and properly labeled every time the tools are withdrawn from the hole. Then, too, as rope measurements are not reliable to within ten to fifteen feet, steel line measurements must be taken frequently, and all these things were done in the present instance, so that the 2,342 feet of strata penetrated from 86 feet above the Pittsburgh coal down to seven feet below the bottom of the fifth oil sand, is represented by 570 samples of drillings, and 55 steel line measurements, from which data a very complete account of all the intervening beds can be obtained, for all of which geologists are certainly under great obligations to Mr. Vandergrift.

The writer will publish the log of the well in the exact language of the party keeping the same, and also a condensed record in more strictly geological terms. I. C. WHITE.

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*Abstract of a paper read at winter (1896) meeting G. S. A.

PERSONAL AND SCIENTIFIC NEWS.

Mr. C. H. Warren has been appointed instructor in mineralogy in the Sheffield Scientific School of Yale University.

Mr. J. H. Pratt, instructor in mineralogy in the Sheffield Scientific School of Yale University, has accepted the position of mineralogist on the North Carolina geological survey.

Warren Upham, secretary of the Minnesota Historical Society sailed May 26th from New York in the American Line steamer "St. Paul," for travel in Great Britain, Scandinavia, and the Alps. He is accompanied by his wife and will return about September 1st.

The Glacial Lake Hamline. In a lecture at Hamline University, St. Paul, Minn., May 6, Warren Upham described the evidences of a glacial lake which covered much of the western part of the area of the city of St. Paul during the departure of the ice-sheet from that district. The most remarkable feature of the glacial geology of the city area was shown to consist in its deposits of modified drift at high levels, forming a group of plateaus of gravel and sand rising with steep slopes to nearly flat upper plains 100 to 125 feet above the highest terraces which represent the old flood plain of the Mississippi river valley. The most conspicuous of these deposits is the extensive high plain crossed by Summit avenue and many other streets, commonly called "the hill." These plateaus tell of a water level peculiar to this area: and the general contour of the region, the sigmoid course of the Mississippi, and two moraine belts, one of northeastern drift in the eastern part of the city, and another of northwestern drift in the western part, imply that this was the site of a glacial or ice-dammed lake, which the speaker had named *Lake Hamline.* The surface of the glacial lake during the early part of its existence, as shown by the Hamline and Como plateaus, was about 250 feet above the present river, or 930 to 940 feet above the present sea level. A little later, when the plateau a mile east of lake Como was formed, the glacial lake had fallen five or ten feet. Still later plateaus show that lake Hamline finally was reduced to 875 to 870 feet above the sea. Its outlet was toward the southwest and south, across the present watershed between the Minnesota and Mississippi rivers, to Rich Valley and the Mississippi. In other words, the mouth of lake Hamline was in the southwest part of Inver Grove township, at a distance of about eight miles southeast of Fort Snelling. The modified drift plateaus formed in lake Hamline are described in a recent paper of the Geological Society of America (vol. viii, pp. 183-196, Feb., 1897, with a map).

Sir Archibald Geikie's visit to America.

The geologists of America have had the opportunity during the last few weeks, of greeting Sir Archibald Geikie, F. R. S., D. C. L., Director-General of the Geological Surveys of Great Britain and Ireland, who has visited this country upon the invitation of the trustees of the Johns Hopkins University to give a course of lectures at that institution. These lectures were provided for by the generosity of Mrs. George Huntington Williams, who thus commemorates her husband, late professor of inorganic geology in that university, who died in 1894. The arrival of Sir Archibald Geikie in New York was marked by a reception which was extended to him upon Monday, April 19th, by the New York Academy of Sciences, in the American Museum of Natural History. Addresses of welcome were delivered by Profs. Stevenson, Kemp, and Heilprin, to which the distinguished visitor responded.

On Wednesday, the 21st, Sir Archibald Geikie began his course of lectures at the Johns Hopkins University upon "*The Founders of Geology*," which embraced a treatment of the rise of geological thought from the days of the cosmogonists down to the opening of the present era. The influence of the older geologists in the development of modern geology was presented in an entirely new light, as the result of the exhaustive researches of the lecturer. Although many attempts at writing the history of geology have been hitherto made, the true significance of many of the earlier views and their first incorporation in the geology of the close of the past and the opening of the present century, had never been fully told. These lectures, which will appear in book form next fall, will add a volume of much importance to the geological treatises of the present day.

Invitations were sent out by the Johns Hopkins University to the geologists throughout the country, more than fifty of whom were in attendance upon all or a portion of the course. Excursions were arranged in honor of Sir Archibald, under the auspices of the Maryland Geological Survey, by Prof. William B. Clark, the state geologist. The shorter excursions took place almost daily, during the season of the lectures, into the region adjacent to Baltimore, including a trip, as guests of the Secretary of the Navy, to the U. S. Naval Academy at Annapolis, where the Cretaceous and Tertiary geology of the Severn river was examined.

After the close of the lectures a longer excursion, occupying four days, was undertaken by the entire party to examine the geological section presented by the state of Maryland. The state board of public works granted the use of the state vessel, "Governor McLane," while the presidents of the several railroads in the state offered free transportation to the participating geologists. Upon the first day of the excursion, Wednesday, April 28th, an extended trip was made down the Chesapeake bay to examine the Cretaceous and Tertiary formations exposed along the bluffs. Returning to Baltimore the party entered their special cars for the western section of the state, where the following day was spent as the guests of the president of the Consolidation Coal company in examining the coal fields of the Alleghenies. The same night the governor of Maryland tendered a reception to the visitors at his home in Cumberland.

Upon the following day the Silurian and Devonian formations of the central Appalachian districts were examined, including a stop at Harper's Ferry, W. Va. The last day of the excursion, Saturday, May 1st, was spent in the Blue Ridge mountains in examining the Cambrian formations and the pre-Cambrian volcanic rocks, the trip closing with a visit to the Gettysburg battle-field. Those who took part in the excursions numbered nearly sixty and were as follows:

F. D. Adams, McGill College, Montreal.
Cleveland Abbe, Jr., of Washington.
R. M. Bagg, Johns Hopkins University.
W. S. Bayley, Colby University.
F. Bascom, Bryn Mawr College.
George F. Becker, U. S. Geological Survey.
L. A. Bauer, University of Cincinnati.
J. M. Clarke, Assistant State Geologist of New York.
Samuel Calvin, State Geologist of Iowa.
W. B. Clark, State Geologist of Maryland.
N. H. Darton, U. S. Geological Survey.
J. S. Diller, " " "
C. W. Dorsey, U. S. Department of Agriculture.
S. F. Emmons, U. S. Geological Survey.
O. L. Fassig, U. S. Weather Bureau.
Sir Archibald Geikie.
D. C. Gilman, Johns Hopkins University.
L. C. Glenn, North Carolina.
R. T. Hill, U. S. Geological Survey.
J. A. Holmes, State Geologist of North Carolina.
C. W. Hayes, U. S. Geological Survey.
J. C. Hartzell, South Carolina.
E. V. d'Invilliers, State Geologist of Pennsylvania.
Lyman C. Josephs, of Newport, R. I.
Arthur Keith, U. S. Geological Survey.
F. P. King, Portland, Maine.
J. F. Kemp, Columbia University.
E. C. E. Lord, U. S. Geological Survey.
F. J. H. Merrill, State Museum, Albany.
W J McGee, U. S. Bureau of Ethnology.
S. W. McCallie, Assistant State Geologist of Georgia.
E. B. Matthews, Johns Hopkins University.
J. A. Mitchell, Mt. St. Mary's College, Maryland.
F. H. Newell, U. S. Geological Survey.
W. H. Niles, Massachusetts Institute of Technology.
Edw. Orton, State Geologist of Ohio.
C. C. O'Harra, Carthage College, Illinois.
J. W. Powell, Bureau of American Ethnology.

L. V. Pirsson, Yale University.
F. B. Peck, Lafayette College.
Heinrich Ries, Columbia University.
Harry Fielding Ried, Johns Hopkins University.
R. D. Salisbury, University of Chicago.
A. C. Spencer, U. S. Geological Survey.
T. W. Stanton, " " "
G. O. Smith, " " "
G. W. Stose, " " "
J. Stanley-Brown, of Washington.
G. B. Shattuck, Johns Hopkins University.
Chas. R. Van Hise, University of Wisconsin.
Lester F. Ward, U. S. Geological Survey.
H. S. Williams, Yale University.
C. D. Walcott, U. S. Geological Survey.
T. G. White, Columbia University.
I. C. White, Morgantown, W. Va.
Bailey Willis, U. S. Geological Survey.
Elizabeth Kirkbridge, Bryn Mawr College.
A. B. Hoen, of Baltimore.

At the close of the visit of Sir Archibald to Baltimore on Monday, May 3d, he passed several days in Washington. On Wednesday, May 5th, he delivered an address before the Geological Society of Washington upon "*Notes for a correlation between the Tertiary volcanic succession in northern Europe and in western America.*" After the lecture a reception was tendered to him by the members of the U. S. Geological Survey. Upon Thursday a visit was made to Bryn Mawr college, where an informal lecture on "Volcanic action in northwestern Europe" was delivered. Upon Friday a brief address was given to the American Philosophical Society in Philadelphia, and upon Saturday he arrived in New York. On Monday, May 10th, a lecture was given before the Brooklyn Institute. Several days were spent visiting relatives and friends in New England and he sailed from New York upon May 15th.

All those who participated in the excursions at the close of the lectures manifested great enthusiasm in all they saw and in the manner they were entertained. The following resolution was drawn up and signed by Sir Archibald Geikie and the entire company of geologists:

To the Board of Commissioners of the Maryland Geological Survey and the State Geologist.

GENTLEMEN: We have spent the last four days in a most interesting inspection of Maryland's geology, under conditions which your hospitable forethought has made peculiarly favorable. Our appreciation of the provisions made for the comfort of the party is keen, and our enjoyment of the excursion has been all that you could have wished it. In twice traversing the state of Maryland, opportunity has been afforded us of observing its mineral wealth, and in coming in contact with a wide range of phenomena illustrative of many of the aspects of geology. The field is rich, and it affords opportunities for inquiries which may add honor and wealth to the commonwealth, contributing at the same time to the sum of human knowledge. The exploitation of these opportunities will be safe under your guidance, and we wish you a speedy success.

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ERRATA.

Page 37, second line, for da, read de.

Page 45, third line, for Skiddau, read Skiddaw.

Page 46, fourteenth line from bottom, for *Enomphalus*, read *Euomphalus*.

Page 47, second line, for interruptedly, read uninterruptedly.

Page 49, twenty-second line, for Mica, read Utica.

Page 115. The Rowe schist should be represented as entirely above the Greylock schist, and the Stockbridge limestone should be represented as in part Silurian and in part Cambrian.

Page 116. The Stockbridge limestone should be represented as "Walcott's Hudson River" (Lower Silurian): and below it should be inserted: *Vermont formation*, Thickness 800 to 900 feet, Walcott's "Olenellus" (Lower Cambrian).

Page 308, twenty-third line, for latitude, read longitude.

Page 308, 18th line from bottom, for latitude read meridian.

Page 310, eighteenth line, after the word glacial, insert and fluvial.

Page 310, 18th line from top, strike out glacial.

Page 316, 11th line from bottom, for Dr. Newberry read Dr. G. M. Dawson (Can. Nat. VIII, p. 249).

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